REPORT RESUMES

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THE PRODUCTION AND EVALUATION OF THREE COMPUTER-BASED
ECONOMICS GAMES FOR THE SIXTH GRADE. FINAL REPORT.
BY- WING, RICHARD L. AND OTHERS
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DESCRIPTORS- GAMES, *GRADE 6, *ECONOMICS, *COMPUTER ASSISTED INSTRUCTION, INDIVIDUAL INSTRUCTION, *SIMULATED ENVIRONMENT, CONVENTIONAL INSTRUCTION, RETENTION, *ACHIEVEMENT GAINS, INTELLIGENCE FACTORS, TIME FACTORS (LEARNING), IBM 7090 COMPUTER, IBM 1401 COMPUTER, IBM 1050 TERMINALS, FORTRAN

THE PURPOSE OF THE EXPERIMENT WAS TO PRODUCE AND EVALUATE 3 COMPUTER-BASED ECONOMICS GAMES AS A METHOD OF INDIVIDUALIZING INSTRUCTION FOR GRADE 6 STUDENTS. 26 EXPERIMENTAL SUBJECTS PLAYED 2 ECONOMICS GAMES, WHILE A CONTROL GROUP RECEIVED CONVENTIONAL INSTRUCTION ON SIMILAR MATERIAL. IN THE SUMERIAN GAME, STUDENTS SEATED AT THE TYPEWRITER TERMINALS PRETENDED TO BE PRIEST-RULERS IN ANCIENT SUMER. IN THE SIERRA LEONE GAME, THE STUDENT PLAYED AN A.I.D. OFFICER. THE THIRD GAME, FREE ENTERPRISE, HAS BEEN COMPLETED BUT NOT TESTED. RESULTS OBTAINED BY OBSERVATION, INTERVIEW, PRE- AND POSTTESTING OF STUDENTS SHOWED THAT (1) GRADE 6 STUDENTS ARE TECHNICALLY ABLE TO PLAY COMPUTER-BASED ECONOMICS GAMES, (2) THE GAMES WERE AT LEAST AS EFFECTIVE AS CONVENTIONAL INSTRUCTION, (3) THE CONTROL GROUP RETAINED AN UNDERSTANDING OF ECONOMIC PRINCIPLES LONGER THAN THE EXPERIMENTALS, (4) THE AVERAGE EXPERIMENTAL TIME WAS ABOUT HALF THE CONTROL LEARNING TIME, (5) STUDENTS WITH HIGHER INTELLIGENCE AND READING ABILITY GAINED MORE FROM THE GAMES, (6) STUDENTS SPENDING THE LEAST TIME AT THE COMPUTER MADE THE GREATEST GAINS, (7) STUDENT INTEREST WAS HIGH. THE SUMERIAN AND SIERRA LEONE GAMES MAY BE PLAYED WHERE A 1401 COMPUTER WITH OPERATING TERMINALS IS LOCATED. OTHER FINDINGS ARE ALSO MENTIONED. APPENDED IS AN EXTENSIVE BIBLIOGRAPHY ON COMPUTER-AIDED INSTRUCTION. (MS)

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June 1967

U.S. DEPARTMENT OF
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THE PRODUCTION AND EVALUATION OF THREE COMPUTER-BASED ECONOMICS GAMES FOR THE SIXTH GRADE

Cooperative Research Project 2841

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with

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June 1967

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The Board of Cooperative Educational Services
First Supervisory District
Westchester County, New York

Yorktown Heights, New York

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PREFACE

In 1962 Dr. Noble J. Gividen, District Superintendent of Schools in Northern Westchester County, New York, suggested to officials of the International Business Machines Corporation that informal talks be scheduled periodically concerning educational research. The logic of this arrangement was that IBM had the technical talent and hardware for research and that the schools had the educational experience on its staff and potential subjects in a dozen school districts. This initial suggestion from the public schools was explored by IBM, and after discussion involving educational philosophy, research, and practice it appeared that a continuing informal relationship would be of considerable help to the schools and perhaps, also, to IBM.

From the general common interest of automation in education, the specific concern for simulated modes of instruction evolved.

In a summer workshop during July and August of 1962 BOCES and the Advanced Systems Development Division of IBM jointly sponsored a summer workshop to explore the possibilities of the simulated environment mode as a method of instruction. Bruse Moncreiff and James Dinneen of IBM directed the workshop with Richard Wing as assistant. Ten teachers from the public schools of Northern Westchester began the study of eight learning units for which individual tutoring could be provided through the aid of audio-visual equipment controlled by a computer. Following this, the BOCES Research Coordinator drafted a proposal which was submitted to the Cooperative Research Branch of the U. S. Office of Education and resulted in the granting of funds for Cooperative Research Project 1948, which lasted from February 1963 to August '64. The results of this project were reported in 1965.

Project 1948 was followed in two-weeks time by Project 2841, subject to the present report. At the suggestion of the U. S. Office of Education, our attention was narrowed from eight topics to one, economic games. In the course of two years three games were produced and two of them tried out on an experimental group of twenty-six sixth graders. The procedures followed in Project 2841 are described in the following pages.

In June 1966 BOCES received a grant under Title III of the Elementary and Secondary Education Act to become a center for demonstration of computer assisted instruction, a closed-circuit television system for training teachers, and a dial selection system. During the first year of the grant approximately one thousand people have visited the center to see demonstrations of the computer-based economics games and the uses of other complex media.

Since January 1967, the computer-based economics games have been supported by a grant from the New York State Education Department.

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PART I: THEORETICAL BASIS FOR THE EXPERIMENT

Although philosophers of education agree that reform is needed in the direction of individualizing instruction, the present educational system is constrained by factors which have produced instead relatively rigid, sterile, and insensitive procedures. Simulation is one method of organizing learning environments to provide for individualization in a broad sense. New technologies have been invented and, to a limited degree, explored for educational uses.

The purpose of the experiment here reported was to produce and evaluate computer-based economics games as a method of individualizing instruction for sixth-grade pupils.

CHAPTER 1: RATIONALE

Assumptions about the Aims of Education

In brief terms, an educational system should provide a learning environment in which each individual can learn those skills, concepts, and attitudes which are appropriate to his own ability and ambitions and improve his character and personality in ways corresponding to an ideal notion of human worth.

Several current philosophies of education provide a reasonable synthesis of educational goals and objectives based on analysis of broader human values. For our purpose the philosophy of John Dewey would be satisfactory.

The broad aims of education have frequently been expressed in terms of "objectives." Many such lists are acceptable. In fact it appears that there is less controversy over the aims of education than over ways of accomplishing the aims.

Next in logical order we need a set of principles drawn from the psychology of learning, perhaps an eclectic synthesis of current hypotheses concerning the circumstances under which learning takes place. Particularly do we need to examine the psychology of individual differences and note the many ways in which students differ from each other.

Inadequacies of Present Educational System

When we proceed from contemplation of educational philosophy and psychology to the state of affairs in the school, the observer needs only common sense to note that implementation falls short of philosophizing. There are many explanations for this discrepancy - mass education, imperfect training of administration and teachers, traditional attitudes in the profession, rising costs and inequitable methods of raising funds, inability of schools to control influences on children outside of the school, pressures from the public, from business, and from government, and the lack of an effective technology of instruction.

The shortcomings themselves include a) organizational inadequacies such as poor articulation between school types; b) curricular defects in the form of rigidity and irrational selection of learning topics; c) sterility of method in such domains as classroom techniques, lack of diagnosis of student need; shortage of effective media and materials; dependence on artificial kinds of motivation; and frequent insensitivity to the enormously varied personalities of the clients of education.

Individualization

Our interest in computer-based instruction is founded on a general dissatisfaction with the quality of education in most schools today, as outlined above, and at the same time on the hope that a theory of instruction based on the broad principle of individualization may provide clues for the improvement of education. This hope comes at a time when the new computer technologies offer promise of new ways of establishing effective learning situations.

An Outline of Activities Fostering Attention to Individual Care of Students.-- A useful basis for discussion of individualization is the proposition that when people talk about individualizing instruction they are really thinking about improvement of the entire educational program of students but with special attention to treating each student as an individual. A logistic orientation is introduced, that is to say that, within a comprehensive theory of education, attention is focused on the problem of supplying adequate instruction to single units of the student body.

This proposition is to be contrasted with the more limited thought that individualization refers chiefly to providing instructional activities performed by one student at a time. Individualization should not mean merely learning in isolation.

If we follow this rationale that individualization applies to all phases of education, we might list these phases under the following headings: a) purposive, b) diagnostic, c) prescriptive, d) instructional, e) evaluative. In the purposive phase the educational philosophy should be reexamined to assure that educational objectives take into account the varying purposes of individuals. Diagnostic practices should be such that they set the stage for learning activities which take into account the varying needs of individuals. A prescriptive phase, often poorly developed in present education, should accommodate the instructional needs to the diagnosis. The instructional activities should include those which provide for the maximum growth of the individual, either in activities which he pursues by himself, or in group activities which are needed for his personal improvement. The evaluation should take into account the individual measured against his own goals and abilities as well as by those of the group.

In the diagnostic, prescriptive, instructional, and evaluative phases there is little doubt that the recent technological inventions can be useful. For example, in all phases more and more information will be needed about students, their needs, and accomplishments. For this purpose improved storage capability is needed. Individual diagnosis in itself will provide us with information which must not only be stored efficiently but interpreted by some electronic means greater than our present manual capability. It also seems likely that complex electronic media may turn out to be a most effective way of providing individualized instruction in some kinds of learning. Really effective evaluation will also require vast storage and logic available perhaps only through electronic means.

Students obviously differ from each other in their state of knowledge or skill, their need to know or learn some skill, their aptitude for learning, and their interest in learning. In some cases these differences may be so extensive that it is clearly pointless to give the same kind of instruction to two pupils at the same time. In another situation, as in the introduction of a new kind of learning, it may be that these differences are insignificant. The first problem here is clearly that of diagnosis. After the diagnosis has been made, suitable materials or methods should be identified and prescribed appropriate to the diagnosed needs. At this point in the sequence the proper instructional techniques should be applied.

The Instructional Phase of Individualization.--The learner is part of a setting which consists of some surroundings, objects which are perceived by the learner through the medium of his senses, sometimes other learners, and usually a person trying to teach him something. Much learning in the life of a school child takes place outside of school in an unstructured fashion and without the conscious effort of someone to train him. In the school the teacher attempts to control the learning by employing a number of techniques, such as lecture, demonstration, question and answer, assignment and home study, discussion, laboratory work, and field trips.

These learning situations differ in respect to

1. Content of learning (main topic, subject).
2. Scope of content; that is, the range of material to be learned.
3. Pace of learning, the rate at which students learn.
4. Sequence or structure, or the order in which topics are presented.
5. Difficulty, depth of the subject matter or learning experience.
6. Mode of sensory presentation or representation, for example, the printed page, films, chalkboard drawings, tape recordings.
7. Control, i.e., by teacher or student or environment.
8. Style, mode; examples might be an inquiry method, *explication de texte*, a Socratic dialogue.
9. Response capability, by which is meant the ability of the teacher or other active elements of the learning situation to react appropriately to what the student says or writes.

In order to provide for individual differences among learners, the learning situation should be adaptable enough to allow appropriate variation in these ways:

1. Change of content
2. Extension of scope
3. Change of pace
4. Alteration of sequence

5. Variation of difficulty

6. Switching of presentation modes

7. Transfer of control

8. Change in style

9. Versatility of response techniques

Learning environments can be differentiated as to their potential for individualizing instruction by their capabilities for providing flexibility in the nine categories above. The individualization will be effective only when there is a combination of these learning circumstances appropriate to the diagnosed characteristics of the individual learner. Theoretically, one measure of success at individualizing instruction is the degree to which the nine procedural canons above are implemented.

Need for Improvement of Present Instructional Methods.-- In the traditional school the teacher usually works with a group of pupils varying in number from twenty to forty, brought together because of a common age in the elementary school and by age and the choice of common subjects in the high school. The teacher may lack detailed information about his pupils and in addition be faced with a very difficult problem of finding appropriate ways of teaching them as individuals. Some teachers, to be sure, are fairly successful in providing a suitably differentiated learning situation for the individuals in a class in spite of the difficulties of making one mind attend to a score or more other minds.

Historically many different ways have been tried out for improving the individualization of instruction by modifying the organization of classes within a school. Sometimes different curricula or tracks have been instituted, as for the honor student and the slow learner. Homogeneous grouping within a curriculum is a common practice as well as the organization of classes. Recently, Advanced Placement Classes have been established in many schools

Other procedures include unit plans, special projects in an independent study program, guidance programs with emphasis on individual advice, and enrichment programs. Add to these the use of teacher aides and lay readers.

Recently physical arrangements such as the learning laboratory, the carrel, the library, and the corner of the classroom have been used to allow for the operation of the new electronic media.

In spite of these tactics we are on the whole still far from successful individualization, and so we should carefully examine the growing repertory of new methods and technological aids to see what contribution they can make to individualization.

Simulation

Definition.--One method of organizing the learning environment and to provide greater individualization is simulation, a technique by which the essential features of some object or process are abstracted and recombined in a model which represents the functions of the original and can be manipulated for the purpose of study or instruction.

The "simulated environment mode" is a special case of simulation in which the emphasis is on simulating the useful features of a learning situation. By "simulated environment" we mean a method of instruction designed to provide individual students with a substitute for the pertinent features of a natural or conventional learning situation and to perform the tutorial functions of a teacher when needed within that setting. This simulation structure is realized through the appropriate selection, organization, and manipulation of instructional materials and the use (ultimately) of audiovideo display and response devices backed up with technical resources, such as a computer, for the storage, retrieval, and processing of information.

Examples.--Some of the best known simulations historically have been engineering devices, such as wind tunnels for testing scale models, the Link trainer, and the present day simulated cockpit of the supersonic transport.

Another form of simulation is the war game defined as "the means for simulating the play of systematic strategy or tactical operation of opposing forces including two-sided maneuvers, chart maneuvers, electronic maneuvers, board games, tactical games, or strategic war games (1)."

Business and management games are used by universities and corporations to train executives. Examples of this are the economic games of Dill(2), the IBM game (3), and the Univac Game (4), in which competitive business situations are simulated and the decisions made by the players are analyzed by a computer to demonstrate to participants the organization, planning, information transfer, analysis, review, interaction, and dynamic nature of business.

Other examples are simulation of medical symptons for training in diagnosis,(5) international relations games, (6,7) and the exercises used to train radar operators in the SAGE system.(7)

Some Distinctions.--In a broad sense simulation is a kind of imitation. Imitation generally consists of copying or mimicking something whose original history, flavor, inspiration, or quality can only be superficially duplicated. In this class we have impersonators on the stage, parrots and Minah birds, and simulated pearls. Related to this connotation is the use of "simulation" to stand for an act whose intent is to deceive, as in the case of camouflage or the pretense of real emotion. When simulation is restricted for our purposes, it does not have the meaning of deception or mimickry. The emphasis is on the abstraction of essential functions for purposes of analysis or education.

Games.--One variety of simulation is gaming. Some writers attempt to make clear distinctions between gaming, simulation, and other related operations; others treat simulation and gaming as roughly synonymous (8). Some games, at least, have the special character of competition between players, or the player competes against the model. In the end someone wins. There is often, too, emphasis on the player assuming a role of some sort. These three features make the game important as a motivating device for students.

Advantages of Simulation for Education.--Simulation enables tests to be made under controlled conditions which would be difficult or impossible in real life. Simulation also permits the compression of time. For example, by the use of time lapse photography a twenty-four hour incubation of bacteria can be shown in a few minutes. The environment in which a student learns contains many features which can be represented by pictures and recorded sound. Laboratory equipment is an example.

Several activities of a teacher can be recorded and presented by audio-visual devices. The lecture, for example, or the demonstration can be recorded by a movie, or television camera and projected when needed.

When data processing equipment, such as computers and their terminals, is available, even the conversational interaction between a teacher and pupil can be simulated to a degree.

A more detailed exposition of the advantages of using a computer for simulation of learning situations may be found in PART IV of the report and Appendix E.

The experiment to be described in PART II was an attempt to capitalize on the simulation mode in order to produce one form of indivudualized instruction.

CHAPTER 2: RELATED RESEARCH

Since we believe that CAI is and should be in an exploratory phase, the current research may be analyzed with this question in mind: what are the aspects of CAI which should be explored and to what extent is this exploration being done?

There are two spheres within which exploration studies should be going on. One is the realm of technology, programing, and invention of materiel. The other is in the domain of school function and operation, including effects on educational systems and opportunities for improvement.

Technical Exploration

In view of the potential for improving education already revealed and the unknown possibilities to be discovered in the future, one would expect many centers to be conducting research on the technology of computer-based instruction, on different programing methods, and on the adaptation of computers to various teaching styles and subjects.

Research Centers Producing Instructional Computer Programs.--The centers we have been able to identify are the Air Force Electronics Systems Division; Bolt, Beranek and Newman; Dartmouth College; Education and Training of Consultants; General Electric; Florida State University; Harvard Computation Laboratory; IBM, Los Gatos; IBM, Poughkeepsie; IBM, Yorktown; Michigan State; MIT MAC; Pennsylvania State University; Philadelphia City Schools; Responsive Environment, Inc.; Stanford; Stony Brook, N.Y.; System Development Corporation; University of California at Irvine; University of California at Santa Barbara; University of Illinois, Training Research Laboratories; University of Illinois, Coordinated Science Laboratory; University of Pittsburgh; University of Michigan; University of Texas; Westinghouse Electric Corporation.

Computer Languages.--Languages for entering instructions to the computer include AUTHOR (Stolurow), BASIC (General Electric), COURSEWRITER (IBM), DOCEO (Bull-General Electric at Liege), JOVIAL (SDC), LYRIC (ETC), MENTOR (BBN), PLANIT (SDC), PLATO (Illinois), TELCOMP (BBN)

Subjects.--Programs have been written for teaching these topics:

- Architecture
- Arithmetic
- Audiology
- Biology
- Chemistry
- Client-centered Counseling
- Computer Programing
- Cost Accounting
- Economics
- Educational Measurement
- Electical Engineering
- Elementary Science
- German
- Health Education
- Library Use
- Mathematics
- Measurement
- Medicine
- Music
- Nursing
- Occupational Guidance
- Physics
- Political Science
- Psychology
- Reading
- Scientific Inquiry
- Spelling
- Statistics
- Stenotypy

As well as some others. Many of these programs are short or fragmentary. At least half are for college-age students or adults.

Instructional Modes.--It is difficult to classify instructional modes exhaustively, but one can identify the styles of didactic presentation (lecture, demonstration), tutorial exchange (Karl Zinn distinguishes between author-controlled tutorial and conversational dialogue), gaming, problem solving, and testing. Hickey and Newton categorize instructional logics under the headings of tutorial (linear, intrinsic, adaptive), Socratic, laboratory (or simulation), and game.

To construct these modes, authors employ a variety of programing strategies ranging from simple branching for linear instructional programs, to more complex, multiple-choice tactics, and to the very complicated techniques of gaming.

It is our observation that programing techniques are generally directed towards classical subject in conventional modes of instruction. There are some noteworthy exceptions.

Gaming Activities.--Experimentation with games has been going on at Johns Hopkins, ESI., ABT Associates, Northwestern University, Nova High School, Carnegie Tech, Cornell, Washington University, Kansas State Teachers' College, IBM, University of Michigan, Ohio State, the Harvard Business School, and La Jolla, California. (See bibliography on games in PART V).

Efforts to Solve Educational Problems

We have listed earlier some persistent educational problems directly or indirectly related to computer technology: scheduling, need or curriculum revision, shortcomings in method, confusion about staff roles, logistics, financial feasibility, facility design, and teacher training. What research is being directed at these problems?

Varieties of Computer Application in Education.--The most widespread use of data processing is for clerical tasks, such as payroll applications, attendance keeping, printing of report cards and guidance records, and scheduling of busses. Recently several programs have been devised to assist in parts of class scheduling.

There are, on the other hand a few new applications directed towards the basic problems of education. S.D.C. has made a study of the specification of procedures for conducting analyses of instructional systems and implications for school organization. Professor Harnack at Buffalo in collaboration with the Erie County BOCES has developed a method of selecting instructional materials to match students profiles. Richard Suchman while at Illinois produced an inquiry mode of instruction. John Easley also at Illinois has worked on some interesting teaching styles. The Bolt, Beranek and Newman medical diagnosis routine is noteworthy as an ingenious use of computer programing to produce a useful teaching style. The game style of program tried out at Johns Hopkins, Northwestern, BOCES, and elsewhere, represents worthwhile efforts to make use of the new technology in a promising mode. Some diagnostic uses of computers for vocational guidance are under study at Harvard and Penn State.

Observations on the Kinds of Research Underway.--Although there is a distinct bandwagon movement towards the use of computers in education at the present writing, our impression of the research in the field is that it has these characteristics:

1. In a certain sense, computer usage for education is a sort of solution looking for a problem. After the hardware has been invented, the engineers look for ways to use it.

2. So far not many centers are engaged in genuine research; only a few new languages for students and instructors have been invented.

3. Most of the practitioners are in the universities and private industry rather than in the schools. Few leaders in curriculum are very much involved.

4. The uses made of CAI could be termed conservative. In spite of the exceptional cases cited in the above section, most CAI is in a conventional mode and directed towards traditional subjects.

5. We are not aware of any completely systematic approaches to the use of computers in schools; that is to say, systems combining diagnostic, predictive, instructional, and evaluative techniques into a whole. (But see Wilber, Rodgers, Gariglio (9))

What we need is joint effort of persons in industry and educators who have vision and a deep understanding of educational problems. There is a great opportunity to make fundamental improvement in educational organization, curriculum, and in method if educators as well as technologists take a strong position of leadership.

CHAPTER 3: OBJECTIVES AND HYPOTHESES

The accomplishment of all the research needed in computer-based education will require collaboration and coordination among many research centers, some concentrating on technical devices, some on programing, and others on educational implications of technology. We conceive our role at BOCES to be one of selecting methods of instruction in important areas of curriculum to be accomplished by new techniques of programing.

The actual objectives and hypotheses in the original proposal for Project 2841 are reproduced here.

Objectives

(1) To prepare materials of some length suitable for teaching through automated instructional technology.

(2) To program this material in the simulated environment mode.

(3) To administer these programs to samples of students.

(4) To measure the effectiveness of this kind of instruction with respect to achievement and speed of learning.

(5) To determine differential effects of independent variables, such as intelligence and reading ability, to the extent that the size of sample will permit.

(6) To measure student attitudes towards instruction in the simulated environment mode.

(7) To improve and expand the exposition of a rationale for simulation which is being written for the current project.

(8) To make available a body of instructional programs with visual components in the simulated environment mode capable of being adapted at computer centers for demonstration in other geographical areas when necessary changes in the computer programs have been made.

Hypotheses

(1) That for certain kinds of instruction in the social studies, use of the simulated environment mode can result in at least as much learning as the use of conventional methods.

(2) That for certain kinds of units the simulated environment mode will be more economical of instructional time.

(3) That for certain kinds of learning, such as the comprehension of economic principles, the game technique will result in the formation of concepts of better quality than those produced by conventional teaching methods.

(4) That the simulated environment mode, at least in the game form, is a suitable method of instruction for the upper elementary grades in the subject field tested.

PART II: DESCRIPTION OF THE GAMES

During the course of Project 2841 three games were developed: The Sumerian Game (already begun in the preceding project), The Sierra Leone Game, and The Free Enterprise Game.

Of these, the first two were used in the formal experiment to be described in Part III and were programed for a special IBM 7090 time-shared computer. The third game was completed after the experiment and was programed in Autocoder for a 1401 computer.

Revisions and reprograming of all games have been continued under a grant from the New York State Education Department covering the period January through June, 1967.

CHAPTER 4: THE SUMERIAN GAME

Background

The idea of constructing a computer model of the ancient Sumerian civilization and using it for teaching basic economics came from Bruse Moncreiff of IBM, who in turn was inspired by Rousseau and Dewey, a paper by Richard L. Meier entitled "Teaching through Participation in Micro-simulations of Social Organization," by the parlor game of Monopoly, and by other experiences with simulation and gaming. The term "simulated environment" was coined by him.[1]

The immediate reason for the choice of the Sumerians was "to protest against the growing tendency in school curricula to ignore the pre-Greek civilizations, in spite of the growing weight of scholarly evidence as to the important role which this prehistory and early history should play in our understanding of the processes by which our society has come to be what it is. Childe and others have identified the development of settled farming - the domestication of food plants and animals - as a necessary forerunner of urban, civilized, social organization. This transformation first occurred in lasting form in the river valleys of Mesopotamia, Egypt, and India. It is ironic that as scholarship was discovering the importance of understanding this technological, economic and social revolution, school authorities were dropping the topic from the social studies curriculum." (10)

The Game

Introduction.-- Preliminary to the programed play of the Sumerian Game there is an introductory lecture. The delivery of the lecture is made utilizing a tape recorder driving a conventional slide projector. During this introduction the student learns that he will play the role as ruler of a city-state in the ancient land of Sumer about 3500 B. C. This introductory presentation takes approximately 20 minutes.

Initial Play.-- At the conclusion of this orientation, brief instructions and the initial economic conditions are typed out for the child at the terminal controlled by the computer. He then assumes the role of Luduga I, priest-ruler of Lagash, and is presented with his first problematic situation: "We have harvested 5,000 bushels of grain to take care of 500 people. How much of this grain shall be set aside for the next season's planting, and how much will be stored in the warehouse? The remainder will be given to the people to eat." [1]

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[1] The instructional version of the game was written by Mrs. Mabel Addis, a fourth grade teacher at the Katonah Elementary School. William McKay of IBM programed the game for the computer.

The child makes decisions and enters his answers at the computer terminal. The computer immediately returns a progress report, including the harvest reaped from the seed grain set aside for planting, a word index as to the standard of living, and a report on his inventory. This kind of problem is repeated throughout the first phase of the game, each harvest representing six months in the life of the ruler. A complicating figure affects the second planting. The ruler must take into account the increasing population. Eventually he is faced with the problem of expansion, which entails the acquisition of new land and irrigation. At intervals the ruler is presented with technological innovations and disasters which will alter his decisions.

The rule of the first Luduga is devoted to the solution of problems pertaining to an agricultural economy. In the second phase of the game, the child as Luduga II is given the opportunity to apply his surplus grain to the development of crafts. In the third and final stage he is introduced to trade and the more complex problems which confront a changing economy. The rate and trend of development are dependent upon the wisdom of the child's decisions.

Details of the Seasonal Play

The first messages introduce the student to the proper use of the terminal and give him an idea as to what his game objectives should be. Following the introduction, the student receives a first Seasonal Population and Harvest Report (FIGURE 1). The reports provide facts about population, acres of land for planting grain, number of farm workers, grain recently harvested, and grain remaining in inventory from previous harvests. The last part of the report asks the student to allocate his resources (grain harvested plus grain in inventory) among three requirements: (1) food for the people, (2) seed for next season's planting, (3) inventory for future needs. Such seasonal reports (a typical seasonal report is shown in FIGURE 2) with their related allocation decisions comprise the basis of play of the entire game.

The passage of time is signified by successive reportings. Good play is signified by a growing population and increasing harvests; poor play, by a decreasing population and/or a decreasing harvest.

The method of computing a change in population from one report to the next is illustrated in FIGURE 3 which shows that the "best" amount of grain to use for food is 18 bushels per person. The formulas used to compute the harvest are displayed in TABLE 1. These formulas do not show the effects of disasters or other temporary variations in harvest. Also, the numbers which appear in the formulas to not remain fixed through a complete play of the game; for example, the formula for the harvest, $H = 4S$, (Item 1) becomes $H = 5S$ after the use of fertilizer in farming is introduced.

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[1] A sample Sumerian Game printout is given in Appendix F.

In the text of a typical seasonal report, the comment, "The quantity of food the people received last season was _________" is modified to read "far too little," "too little," "satisfactory," "too much," or "far too much," depending upon the amount of grain allocated for food. The rules for insertion of the ratings - far too little, etc. - are shown in TABLE 2.

Random Disasters.--Immediately following the seasonal report, there occasionally occur other brief reports of events which alter conditions in the city-state. The most persistent happenings are natural disasters - floods and fires which kill people and ruin harvests. These natural disasters point up the need for maintaining a well-stocked inventory. The occasion and severity of the disasters are both determined by an Operation Research method known as the Monte Carlo method. Here use is made of a sequence of numbers, each sequence being computed as needed with the statistical property referred to as "randomness" (each of the possible values are equally likely to be picked, each selection is a statistically independent one). A computation for generating a sequence of "pseudo-random" numbers is shown in TABLE 3; they are termed "pseudo-random" because they are reproducible rather than obtainable by pure chance. A single computation generates a single number of the sequence.

The flowchart in FIGURE 4 shows a procedure for determining whether or not a disaster should occur, and if one is to occur then with what severity? The procedure, repeated a number of times will show disasters occurring 5/16 of the time overall. The severity of a disaster is reflected in the magnitude of a reduction in the harvest. The reduction may be 10%, 20%, 30%, or 40% and these percentages are chosen 9/16 of the time, 4/16 of the time, 2/16 of the time and 1/16 of the time, respectively.

Grain Rotting.--Another report frequently following the seasonal report, has to do with the rotting of grain left in inventory. The comment, "Sir: I am sorry to report that _______bushels of grain have rotted or been eaten by rats this past season," is given to the student if the amount of rotted grain is not zero. The calculation of the amount is given in TABLE 4.

Innovation Reporting.-- The economic condition of the city-state may improve in two ways: (1) through good management of the basic grain allocation, (2) by accepting with some good judgment a sequence of innovations presented in special end-of-season reports. Improvements of the second kind show themselves dramatically - a harvest productivity parameter is increased by 25%, the rate of rotting is cut by 50%, or perhaps the number of farmers required per acre of land is reduced by 50%. Progress through the game can be measured in terms of the number of special reports gone over by the students. Normally, a strict sequence is followed for the special reports; no report can be given until some specific predecessor has been given. Some of the reports are not offered to the student until after the student has exhibited some "good" judgment; e.g. he has fed his people satisfactorily for two consecutive seasons. As each of the reports is given (the student is often required to respond to questions during the reporting), any variable of a collection of state-of-the-nation variables may have its value altered. Such alterations invariably show themselves in subsequest population and harvest reports.

A description of all the state-of-the-nation variables used in the Sumerian Game is included in TABLE V. Variables are shown in two groups, the first containing variables for which values are maintained as of the current time of play, as of the time one season ago, two seasons ago and three seasons ago. This brief "history" is maintained as the source of information for making judgments as to the "goodness" of play. The second group of variables are for current play-time only.

Three Parts - Three Rulers.--The Sumerian Game is played in three successive parts, the sequence of parts corresponding with the reign of three successive rulers: Luduga I, II and III. In addition to contributing to the story line of the game, this organization of the game makes plausible the resetting of the state-of-the-nation variables. That is, no matter how a student has directed the city-state through his reign as Luduga I or II (he may, for example, have increased his population by 20% or decreased it by 30%), he would start his play in the role of Luduga II or III with a standard set of values for the state-of-the-nation variables. The story line explanation is that a period of time elapses after the time of completion of one part before the start of the next.

Revision of Game

After the experience of having some thirty pupils play the game and take the tests and of listening to consultants, it was decided to make extensive revisions during the summer of 1966.

Mrs. Addis made an amplification and clarification of the objectives and facts, generalizations, and concepts implied in the scripts of the three rulers. Each concept was extended to show how it was incorporated in the game. The next step was a revision of the parameters with a view to making them more realistic. The script of the first ruler, Luduga I, was rewritten. The number of plays made by the student was reduced to thirty with the messages condensed to reduce the repetitious nature of the economic reports. Visuals, formerly used as motivational and illustrative devices, were improved to contribute directly to learning. Graphs and charts were included to enhance and review the explanation of economic concepts. These concepts were spelled out further by the introduction of mid-season court bulletins. Since the earlier approach relied heavily upon the printed word as a means of communicating with the student, a diversification in the range of learning in-put was introduced by the use of the tape recorder. In a series of problem-solving situations the ruler was given the opportunity to listen to a tape which recorded the simulated discussion of a cabinet of advisors. At the conclusion of each tape he was redirected to the printed word of the terminal to record his decisions. The introduction of an audio court news bulletin also relieved the reading routine and added interest to the play.

The form of the game representing the reign of the second ruler was changed completely in format. Reduced in length to ten plays, the lengthy procedure involved in the plant, harvest, storage decision making was eliminated. These calculations were assumed by the computer, thereby leaving the student free to concentrate on the major problem of allocating manpower. Justification for this revision lay in the assumption that the successful conclusion by the student of the first segment of the game would indicate a certain degree of mastery of the allocation of resources problem.

The script for the first segment of the Sumerian Game has been reprogramed by Jimmer Leonard, graduate student in the Social Relations Department at the Johns Hopkins University, in Autocoder for use on an IBM 1401 computer at the University. The program is now being transmitted for demonstration purposes to terminals located at the BOCES Research Center in Yorktown Heights, New York.

Alternate plans have been drawn up for a revision of the third segment of the game. The first would retain the earlier format of Luduga III, requiring the student to manipulate the decisions of grain and labor allocation as well as introducing the new problematic situations of trade, colonization, and war. The primary purpose for retaining the decision-making elements of the first two rulers in the third would be for reinforcement and review. The second version would employ the abbreviated economic report of the second ruler with the computer doing the mathematical calculations, and the student would confront problem solving situations arising from a more complex society. New visuals and audio tape materials have been introduced into this third and last segment of the game.

Economic Principles in the Sumerian Game

The Sumerian Game play is not derived from a systematic economic theory, but rather the principles and guides to action exemplified in the game are those thought by the authors to be inherent in the situation and at the same time recognized by authorities in the field[1] as reputable principles of economics.

Following is a list of the economic principles in the original version of the game. Each principle is followed by a statement telling how the student was expected to learn it.

---

[1] Consultants for this game have included Vaughn Crawford, Asst. Curator, Ancient Near East, Metropolitan Museum of Art, New York City; George Dawson, Head of the Social Studies Division, School of Education, New York University; and Martin Anderson, Associate Professor of Business, Columbia University Graduate School of Business.

Luduga I

I. In a centrally directed economy the ruler determines what is to be produced.

> Luduga makes all the decisions pertaining to planting and craft establishment.

II. Since human wants are greater than the resources available to satisfy these wants, societies must find ways of allocating their resources efficiently.

> From the initial play of the game on, the student has to face the problem of how to allocate his grain.

III. Efficient allocation of resources benefits society; inefficient allocation reduces the total wealth of a community.

> If too little grain is saved for planting, Luduga's people starve to death; the loss of people is a serious loss of an important factory of production -- labor.

IV. Savings and investment are necessary if society is to enjoy consumption in the future. A certain amount of current consumption must be sacrificed if we want to consume in the future.

> If Luduga saves too little grain, the next year's harvest may not be enough to feed his people.

V. The economic system attempts to find the proper balance between consumption, savings, and investment.

> There is one best ratio wherein Luduga sets aside a certain amount of grain for planting, a certain amount for inventory, and a certain amount for consumption.

VI. A knowledge of economic facts and principles can help us to make predictions, but these predictions can be upset by uncontrolled variables.

> If the student masters the proper ratio in the game, his predictions can still go awry because of random disasters.

VII. Economic growth is necessary if the standard of living is to increase. An economy is growing when there is an increase in real per capita output.

> Luduga must increase his grain output to meet his growing population.

VIII. The real cost of anything is what we must sacrifice to get it.

The cost of Luduga's clay pots is the amount of grain lost by the fact that labor was taken from the fields to make pots.

IX. Improvements in productivity can lead to economic growth and greater national wealth.

Technological innovations enable Luduga to increase his output. This, in turn, permits him to devote a smaller percentage of his total resources to the production of necessities.

X. As more labor and capital are used by a producer on a piece of land, a point is reached where his return becomes less in proportion to the amount of labor and capital used.

If Luduga continues to increase his planting figure on the same number of acres, his harvest will eventually decrease.

XI. When the optimum yield on a given acreage has been reached, and the population continues to increase, it is necessary to cultivate more land.

As population grows, Luduga is given the opportunity to increase his acreage.

XII. Climate, seasons, and natural resources affect how a man provides for his basic needs.

It was possible for Luduga I to harvest much more grain than he planted and thus make farming the primary occupation because of the natural conditions which existed in Sumer.

XIII. Disasters require a redistribution of resources.

When Luduga is faced with a disaster to his harvest or people, it often necessitates a re-allocation of resources.

XIV. The effects of disasters can be alleviated by savings.

Luduga frequently overcomes the effects of disaster by using the savings in his Inventory.

Luduga II

I. An increase in production in one sector of an economy may release factors of production for service in other sectors.

An increase in farming production releases labor for service in crafts in all three rulers, but especially in Luduga II.

II. Specialization tends to increase efficiency.

Luduga is told this when he begins to set up crafts.

III. The real cost of anything is what we must sacrifice to get it.

Sending too many men to get timber reduced the grain harvest. The real cost of the timber was the lost grain.

IV. Technological improvements increase productivity.

Crop rotation, the adoption of the plow, the potter's wheel and the wheel all increase productivity in their related areas.

V. When we successively apply equal amounts of one or two factors of production to the remaining factor or factors and find that an added application yields a smaller increase in production than the application immediately preceding, we have the Law of Diminishing Returns.

In Luduga II the watering of the barley, and the existence of too many basket makers illustrate this law.

Luduga III

I. Social capital is a necessary element of any economy, and must often precede broadly-based economic development.

In the Sumerian Game social capital covers such things as schools, canals, roads, and other projects which do not usually result in profit.

II. Trade for desired commodities is preferable to raiding because:

a. The high element of risk in raiding makes it costly. Luduga loses his raiding parties on several expeditions.

b. Trading opens up markets for surplus projects. Luduga trades surplus grain for timber and metal.

III. Since water is essential to an agrarian economy, it is imperative that irrigation canals be maintained and improved.

Luduga copes with the problem of silt removal, keeps canal guards, and builds a new dam and system of irrigation ditches.

IV. A commodity is used for exchange when there is a demand for it in the market, when it provides a better rate of exchange, or when there is a surplus of it at home.

Luduga uses grain in his early trade transactions because of these reasons.

V. When a ruler has a choice of commodities to be placed in trade, whenever possible he should choose the one

a. of which he has the greatest surplus.

b. for which there is the greatest demand.

c. for which there is the best rate of exchange.

Luduga faces a choice among grain, wool or cotton, where wool is preferred.

VI. When an invention increases the output of a product beyond the demands of home consumption, it is possible to put that product into trade.

The invention of a loom enables Luduga to use his surplus wool for trade.

VII. Although a part of the cost of a product goes to the middleman, this is compensation for performance of valuable services and contributes to the efficiency of resource allocation.

Luduga uses the middleman at Mari because it saves travel time and eliminates the risk of travel in the dangerous hill country.

VIII. A country may profitably specialize if it has a greater advantage in producing one commodity than in producing another.

Luduga produces barley and buys cotton because it is more to his advantage to raise the grain which feeds his people and gives him buying power.

IX. To keep the morale of his people high, it is advisable for a ruler to introduce into crafts and trade luxury items as well as necessities.

Luduga trades for precious stones for the adornment of his temple.

X. Increased government production, as for war materials, takes resources away from civilian goods.

Luduga faces the decision of transferring men from his fields and crafts to meet the increasing demand for war materials.

IX. Every economy should attempt to conserve its natural resources.

Luduga protects his natural resources with the construction of an intricate system of canals and dams.

The concepts outlined under Luduga's I and II are repeated for reinforcement in Part III.

TABLE 1. FORMULAS RELATING HARVEST TO SEED PLANTED, LAND CULTIVATED AND NUMBER OF FARMERS

Symbol Definition:

Let H = the number of bushels in the harvest

S = the number of bushels of seed planted

L = the number of acres of land cultivated

W = the number of workers on the farm lands

Formulas:

1. If too much seed has not been planted

$$S \leq 6\ L$$

and if there are enough farmers

$$W \geq L/4$$

then

$$H = 4S$$

2. If too much seed has not been planted

$$S \leq 6\ L$$

but there are too few farmers

$$W < L/4$$

then

$$H = (4 \cdot W/L)\ 4S$$

3. If too much seed has been planted

$$S > 6\ L$$

and if there are enough farmers

$$W \geq L/4$$

then

$$H = 24\ L$$

4. If too much seed has been planted

$$S > 6\ L$$

and there are too few farmers

$$W < L/4$$

then

$$H = 96\ W$$

TABLE 2. MESSAGE INSERTS

Let the comment "The quantity of food the people received last season was _________"
have a variable insertion, to be specified below:

Let X = food per person in one season (see Figure 1); then

If $X < 9$ the insert is "far too little."

If $9 \leq X \leq 15$ the insert is "too little."

If $15 < X < 21$ the insert is "satisfactory."

If $21 \leq X < 27$ the insert is "too much."

If $27 \leq X$ the insert is "far too much."

TABLE 3. PSUEDO-RANDOM-NUMBER GENERATION

Let R = the current value of the random number, $0 < R < 1$ then compute:

R_1	=	$2^{35}R$	an integer with a 35-bit binary representation.
R_2	=	$1220703125\ R_1$	an integer with a 70-bit binary representation.
R_3	=	$R_2 \text{MOD}\ 2^{35}$	an integer less than 2^{35} with a 35-bit binary representation.
R	=	$R_3/2^{35}$	a number less than 1 with a 35-bit binary representation.

The MOD 2^{35} notation above means to take the remainder of R_2 after subtracting away all positive multiples of 2^{35}. This is conveniently done on a binary computer with 35-bit registers simply by forming the 70-bit product and then dropping the leading 35 bits.

TABLE 4. THE GRAIN ROTTING COMPUTATIONS

Let I_0 = grain put into inventory this past season
I_1 = grain put into inventory one season back
I_2 = grain put into inventory two seasons back
I_3 = grain put into inventory three seasons back
ΔI = the change in inventory due to rotting

There are four rates of rotting. The applicable rate is determined by other factors, e.g. the extent of the use of clay pots, rather than baskets, for the storage of grain.

$$\Delta I = .1\, I_0 + .25I_1 + .75I_2 + I_3 \tag{1}$$

$$\Delta I = .75I_2 + I_3 \tag{2}$$

$$\Delta I = I_3 \tag{3}$$

$$\Delta I = .5I_3 \tag{4}$$

TABLE 5. STATE-OF-THE-NATION VARIABLES

FOUR TIME PERIODS

The first group of variables have values maintained as of 4 distinct points in time (simulated play time). They are the current seasonal report time, seasonal report time 1 season ago, seasonal report time 2 seasons ago and seasonal report time 3 seasons ago.

P - the population
F - the amount of grain allocated for food
H - the amount of the harvest
S - the amount of seed planted
L - the number of acres of land under cultivation
W - the number of workers in farming
I_0 - the amount of grain in inventory zero seasons old
I_1 - the amount of grain in inventory one season old
I_2 - the amount of grain in inventory two seasons old
I_3 - the amount of grain in inventory three seasons old

CURRENT PLAY TIME ONLY

Values of the following group of variables are maintained only for the current-play time.

R_0 - the normal rate of return - harvest to seed planted
R_1 - the maximum ratio of seed planted to land cultivated for normal harvests
R_3 - the minimum ratio of farm workers to land cultivated for normal harvests
R_4 - the ratio of farm workers to total population
Y - the number of seasons played

```
Initial Economic Report Made to the New Ruler of Lagash by his Humble Steward:

Total population now                                   500
Total farm land under cultivation, acres               600
Total grain in inventory, bushels                      900
    one season old                                     900
    two seasons old                                      0
    three seasons old                                    0
Total grain just harvested, bushels                  13000
Total resources, harvest and inventory               22000
You must now decide how to use your resources.
How many bushels of grain do you wish to feed your people?
........
How many bushels of grain do you want planted for the next crop?
........
This means that........bushels must be placed in storage.  Is this all
right?  Do you wish to (1) let your decisions stand, or (2) revise them?
........
Resulting inventory                                   ........
The steward will execute the royal commands and return in 6 months.
```

FIGURE 1. THE INITIAL SEASONAL REPORT

```
Economic report of the ruler's steward for the fall season in the year 14 of
Luduga 1.

Population at previous report                                      514

Change in population                                                12

Total population now                                               526

The quantity of food the people received last season was satisfactory.

Harvest last season                                              15829

Harvest this season                                              15829

Previous inventory                                                2620

Change in inventory                                               -456

Present inventory                                                 2164

Total resources, harvest + inventory                             17993

You must now decide how to use your resources.

How many bushels of grain do you wish to feed your people?

9500

How many bushels of grain do you want planted for the next crop?

4500

This means that 1829 bushels must be placed in storage.  Is this all

right?  Do you wish to (1) let your decisions stand, or (2) revise them?

1

Resulting inventory                                              3993

The steward will execute the royal commands and return in 6 months.
```

FIGURE 2. A TYPICAL SEASONAL REPORT

Let P = the population

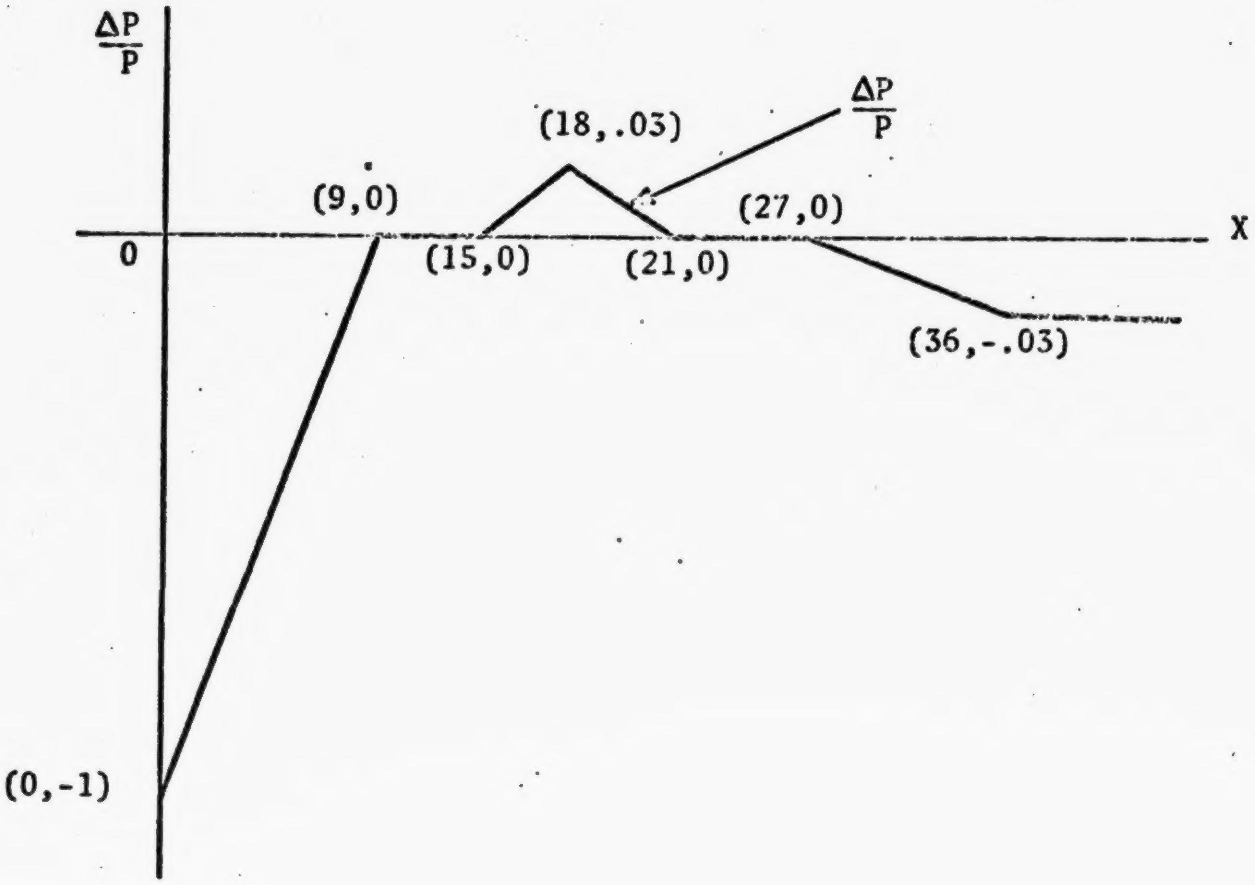
ΔP = the change in population over one season

F = the number of bushels of grain set aside as food for one season

X = food per person in one season

then $X = F/P$

and the ratio $\Delta P/P$ is given in the graph below:



Example: If $P = 600$ and $F = 10{,}200$

then $X = 17$; $\Delta P/P = .02$

and $\Delta P = 12$

The next population figure would then be 612.

FIGURE 3. GRAPH RELATING POPULATION CHANGE TO FOOD CONSUMPTION

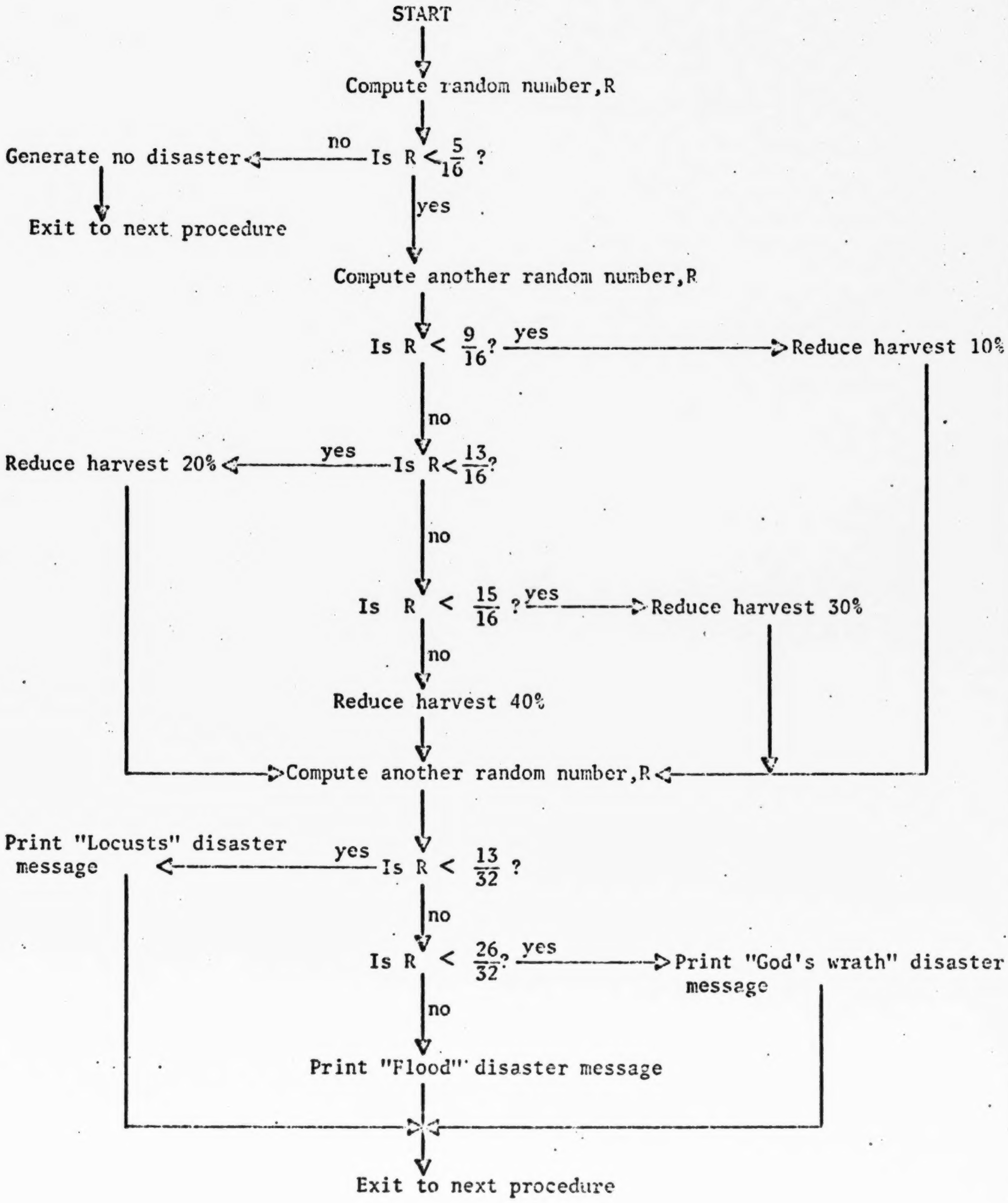

START
Compute random number,R
Generate no disaster
no
Is R < 5/16 ?
yes
Exit to next procedure
Compute another random number,R
Is R < 9/16?
yes
Reduce harvest 10%
no
Reduce harvest 20%
yes
Is R< 13/16?
no
Is R < 15/16 ?
yes
Reduce harvest 30%
no
Reduce harvest 40%
Compute another random number,R
Print "Locusts" disaster message
yes
Is R < 13/32 ?
no
Is R < 26/32?
yes
Print "God's wrath" disaster message
no
Print "Flood" disaster message
Exit to next procedure

FIGURE 4. NATURAL DISASTER GENERATION PROCEDURE

CHAPTER 5: THE SIERRA LEONE GAME

The setting for the second game was selected by the author of the game, Walter Goodman, because he felt that the economic problems of newly-independent African countries were important for pupils to understand. Sierra Leone in 1964 seemed like a representative African state where political factors were less critical in determining economic developments than in other African lands. We were also fortunate to have Frank Karefa-Smart from the Sierra Leone U.N. staff available for consultation.

The subject matter of a given game part is quite independent of the subject matter of other game parts. In the Sierra Leone Game, the student's role is that of an American economic advisor. Points are awarded the student as he progresses through each part of the game. A certain preassigned number of points must be acquired by the student to earn each one of three titles offered: Second Assistant Affairs Officer, First Assistant Affairs Officer, Chief Affairs Officer. The game is opened by handing the student a sheet entitled "Background on Africa" to read before he starts play at the terminal. This sheet, in addition to explaining why the U. S. Government helps the newly emerging nations, also describes the point-rating system and job promotion possibilities.

The beginning of play at the terminal involves an introduction to the use of the terminal, and an explanation of a method usable by the student to obtain definitions of key words. Key words are printed in red as part of messages sent to the student. At the end of a sentence containing a key word, the typewriter carriage is returned, the green "Proceed" light comes on and the keyboard is unlocked. The student must then respond by typing: (1) the letter "W" which causes the key word definition to print, (2) a previously appearing key word which causes that key word definition to print, or (3) nothing - actually no response followed by an end-of-message indication - causing the word definition procedure to be skipped.

Picture and Word Tour

The first part of the Sierra Leone Game, after the introduction, takes the student on a picture and word tour of Sierra Leone. A linear program of lectures, slide presentations, questions and answers, and simple branchings is used. This is followed by a formal examination, after which the student is given his earned title (or not) and "sent-off" to his first job in the Northern Province of Sierra Leone.

Northern Province

Here the student must manage a cooperative farm where he is expected to increase the production of onions. A Farm Operations Report (FIGURE 5) is presented to the student seasonally. During the first part of the play, the following remark and question are put to the student: "You have up to _________ leones to spend on the land. How much will you spend this season?" FIGURE 6 shows a flowchart which describes the sequencing of the seasonal reports. The flowchart also gives the formulas used for computing the variable report entries. Note that the value of F, the average of the amount spent on land each season, will never exceed 100. Good play, which is to always spend all of the money allotted for land, will tend to increase F rapidly at first, but more slowly later. As F approaches 100, the onion production, P, approaches 5000. The report entries, Labor Expense and Equipment Expense, remain constant through this part of the play - 1000 and 150 leones respectively.

Capital Expenditure--In a second part of play, still in the context of farm management, the same seasonal report is used, but a different question is put to the student: "You may now borrow up to 1500 leones for equipment. How much do you want to borrow this season?" The corresponding report generation flowchart (FIGURE 7) specifies that seasonal equipment expenses are 400 (a fixed amount) plus E (the amount borrowed). Since this sum cannot exceed 1900, neither can the average equipment expenses, G. This limitation, in turn, limits onion production to a number less than 10,000 bushels. Good play here entails borrowing the maximum amount each season in order to push onion production to its maximum. The increase in production is most dramatic at first, but tapers off as production approaches 10,000. The report entries, Labor Expense and Land Expense, remain constant through this part of play - 2000 and 200 leones respectively.

Labor--A third part of play, again in the context of farm management, makes use of the same seasonal report, although a still different question is put to the student: "You may now hire up to three new workers. How many will you hire this season?" The corresponding report generation flowchart (FIGURE 8) shows that good play in this part requires the labor force be built up to and maintained at a level of 14, 15, or 16 workers. Onion production, as well as labor, equipment, and land expenses, rises linearly with the number of workers. A maximum production of 10,000 bushels occurs when the number of workers, N, reaches 15.

A player is or is not given a new title depending upon performance while in the Northern Province. He then leaves his job on the farm, and is sent to the Eastern Province for his next assignment.

Eastern Province

Here the student must direct the Production Marketing Board of the Pendenbu Agricultural Station. He must buy in a free rice market a portion of the rice food supply each month for the people of the area. The student can see the effects on price and supply as he carries out his buying policy (demand). The Rice Market Report (FIGURE 9) on which purchases are based, contains the appropriate money T. FIGURE 10 shows the monthly rice report generation flowchart. The flowchart shows that if the quantity, Q, of rice bought is equal to 80% of the supply, then there will be no change in next month's price and also no change in next month's supply. If Q is greater than 80% of S, then P and S tend to go up; if Q is less, they tend to go down. P is constrained to values between 95 and 125 leones, and S is constrained to values between 1 and 8 tons. The closer P is to 95 (125) the smaller is the allowed change toward 95 (125). There is a similar behavior for S between values 1 and 8.

For reasons of clarity, the flowchart illustrating the generation of the monthly Rice Report (FIGURE 10) shows none of the controls necessary to stop the monthly reporting cycle. Actual control of the sequence of monthly reports is complex. Every 3, 6, 9, and 12 months, special summarizing reports are presented to the student. After 24 months of simulated play, the student's responses are judged to be good if he bought an adequate amount of rice over the two-year period, or not good, if he bought less. If good, the student goes on to his next job; if not, the student spends another "year" in the rice market. After 36 months of play, the student is judged once again. Again he may go on to his next job or be sent back for one more year of rice buying. After 48 months, the student must be sent on to his next job.

Diamond Market--The second job given to the student while he is in the Eastern Province requires that he decide the quantity of diamonds to be supplied to the local diamond market. The monthly Diamond Market Report (FIGURE 11) shows the month, the numeric value of the demand, D in carats, and the price, P in leones.

The corresponding flowchart (FIGURE 12) describes the generation of the diamond reports. Twelve reports are shown to each student. Student responses in no way affect the monthly demand or price. In fact, as the flowchart shows, the student-determined supply figures are rigidly guided to fall between 75 and 85 percent of the demand for that month. The variation in demand and price over the 12 months' play is shown in the i, D, P table of Figure 12 and is only a reflection of natural seasonal variations.

The diamond market play is intended to serve as a contrast to the rice market play - a rigid market versus a flexible one. Additional controls are available to signal which specific short lectures should be given following the 3, 6, and 9-month reports. These lectures point out the contrast-of-markets story.

At the end of the play in the Eastern Province, the student is or is not given a new title depending upon his performance in the rice market, and is then sent on to the Southern Province of Sierra Leone. There he is to do some very important work in the City of Freetown, capitol of Sierra Leone.

Southern Province

Here the student is given an assignment in the Government Office Building. He is required to direct the spending of government monies in the support of agriculture, mining and manufacturing. Before each of his subsidy allocation decisions, the student sees a GNP (Gross National Product) report (FIGURE 13) which shows the total amount of the GNP and the amounts of Mining, Manufacturing, and Agricultural expense.

Agriculture--The student must first decide the percentage of the total subsidy which goes toward the agricultural sector of the economy. Then the following remark and question: "You have up to ______million leones to spend. How many millions do you want to spend on agriculture?" are put to the student immediately following each GNP report. The flowchart (FIGURE 14) describes the sequencing of the reports and the formulas used to compute the variable entries in the report. Again for reasons of clarity, the control procedures for ending play are omitted. The chart shows that $\bar{A}$ (the percentage of the GNP produced by the agriculture sector) will increase or decrease as x (the percentage of the total subsidy put into the agriculture sector) is greater than or less than the last value of $\bar{A}$. The value of $\bar{A}$ may vary, as shown in FIGURE 15, for the entire range of x(0 x 1), and for each of the possible values of the last value of $\bar{A}$. As an example, if .6 were the last value of $\bar{A}$, then the new value of $\bar{A}$ must be between .64 (when x = 1), and .54 (when x = 0). Figure 16 shows the relationship between the GNP and $\bar{A}$, and that "good play" of the game would be to direct the value of $\bar{A}$ toward .4.

Mining--After having raised the GNP to a value close to 160 million leones, the student is complimented, then asked to redirect his attention to the mining sector of the economy. The same GNP report is given, though with a different remark and question following it: "You have up to _______million leones to spend. How many millions do you want to spend on mining?" FIGURES 17, 18, and 19, respectively, are completely analogous to FIGURES 14, 15, and 16. Note, that in FIGURE 18, when the "Last value of $\bar{M}$ is .6, then the "new value of $\bar{M}$" must lie between .5 (x=0) and .67 (x=1).

FIGURE 18 shows that "good play" would direct the value of $\bar{M}$ toward .25.

Manufacturing--A third part of "play" in the Southern Province has the student directing government spending in the manufacturing sector of the economy. FIGURES 20, 21, and 22, respectively, show the flowchart of the report generation procedure, the graph of the rule for transforming a student's response to a next value of F, and the graph of GNP vs. the manufacturing subsidy. These illustrations are analogous to FIGURES 17, 18, and 19 of the mining assignments and to FIGURES 14, 15, and 16 of the agriculture assignment. "Good play" in this part will increase the GNP to around 400 million leones by directing the value of F toward .70. When the student has accomplished the game objectives (GNP around 400 million leones), he is congratulated for successful completion of his job, and returned to the U.S.

Objectives of the Sierra Leone Game

The student should learn--

I. Introduction:

   A. Some understandings about the problems of newly independent countries in Africa.

   B. Certain facts about the geography and recent history of Sierra Leone.

   C. Some technical terms from economics.

The student should understand that--

II. Northern Province

   A. It is desirable to raise agriculture above the subsistence level and continue to raise it.

   B. Agriculture operated on a large scale becomes more efficient.

   C. Law of Diminishing Returns operates when excessive labor and capital are invested on a single piece of land.

   D. Since innovations such as contour plowing and crop rotation increase productivity, farmers should seek information about new methods from available sources.

   E. Variation in the three main factors of production (land, labor and capital) increases production.

   F. A favorable balance of trade exists when exports exceed imports.

III. Eastern Province

   A. In an uncontrolled market (rice) a flexible supply-price relationship exists.

   B. A few companies operate the diamond market and exercise monopolistic control of it.

IV. Southern Province

A. Three procedures by which the Gross National Product may be increased are:

1) Avoiding over-reliance on one crop (palm kernel) and decreasing reliance on agriculture in general.

2) Avoiding over-reliance on one industry (mining), which provides easy, quick revenue but which over a long period of time is harmful to the economy.

3) Steadily and rapidly strengthening the manufacturing segment of the economy.

Board Game

The computer-based games unfortunately combine two variables - games and computers in such a way that we cannot differentiate the effects of the configurations.

With this and other considerations in mind, we contracted with ABT Associates to have a board version of the Sierra Leone game made. This manual game was completed in June 1966. It consists of a large board, equipped with cards, deals, scoring areas, and places for four players. Essentially it follows the plot of the computer version with variations made necessary by the nature of manual play.

During the summer of 1966 this single board version was tried out on eight subjects. Students who played the game were: two ninth graders, four tenth graders, one eleventh grader, and one college freshman. Two groups of four students played the game. The first group played three afternoons with total playing time four and one-half hours; the second played three and one-half hours in two sittings.

These students were interviewed after playing the game. The topics of the interviews and reactions of the students are given below.

Student Observations on Sierra Leone Board Game

A. What aspects of the game needed improvement? Suggestions on how to improve these aspects?

1) Three felt game was too long, boring, needed more variety.
2) Two felt diamond part of game needed better scoring system.
3) Two felt black message cards not necessary.

B. What aspects of the game did you find appealing? Why?

1) Four found the play in the Southern Province exciting and different.
2) One liked the play in the Northern Province.

C. Describe the important economic principals behind the play in the Northern Province.

1) Five were substantially correct.
2) One was vague.

D. Describe the important economic principals behind the play in the Eastern Province.

1) Three were partially correct in analyzing the rice segment of the game.
2) Five were incorrect or vague in analyzing the diamond segment of the game.

E. Describe the important economic principals behind the play in the Southern Province.

1) Two were correct in analyzing the GNP movements.
2) Two were incorrect in analyzing the GNP movements.
3) One was partially correct in analyzing the GNP movements.

Labor expenses last season ____________ leones

Equipment expenses last season ____________ leones

Land expenses last season ____________ leones

Onion Production ____________ bushels

FIGURE 5. FARM OPERATIONS REPORT

Let L = land expenses (leones)
M = money available for land expenses (leones)
P = production of onions (bushels)
F = a weighted average of past land expenses (leones)

Other symbols in the formulas are only used for computational convenience. Initial values for L, M, P and F are 50, 100, 3000, and 50, respectively.

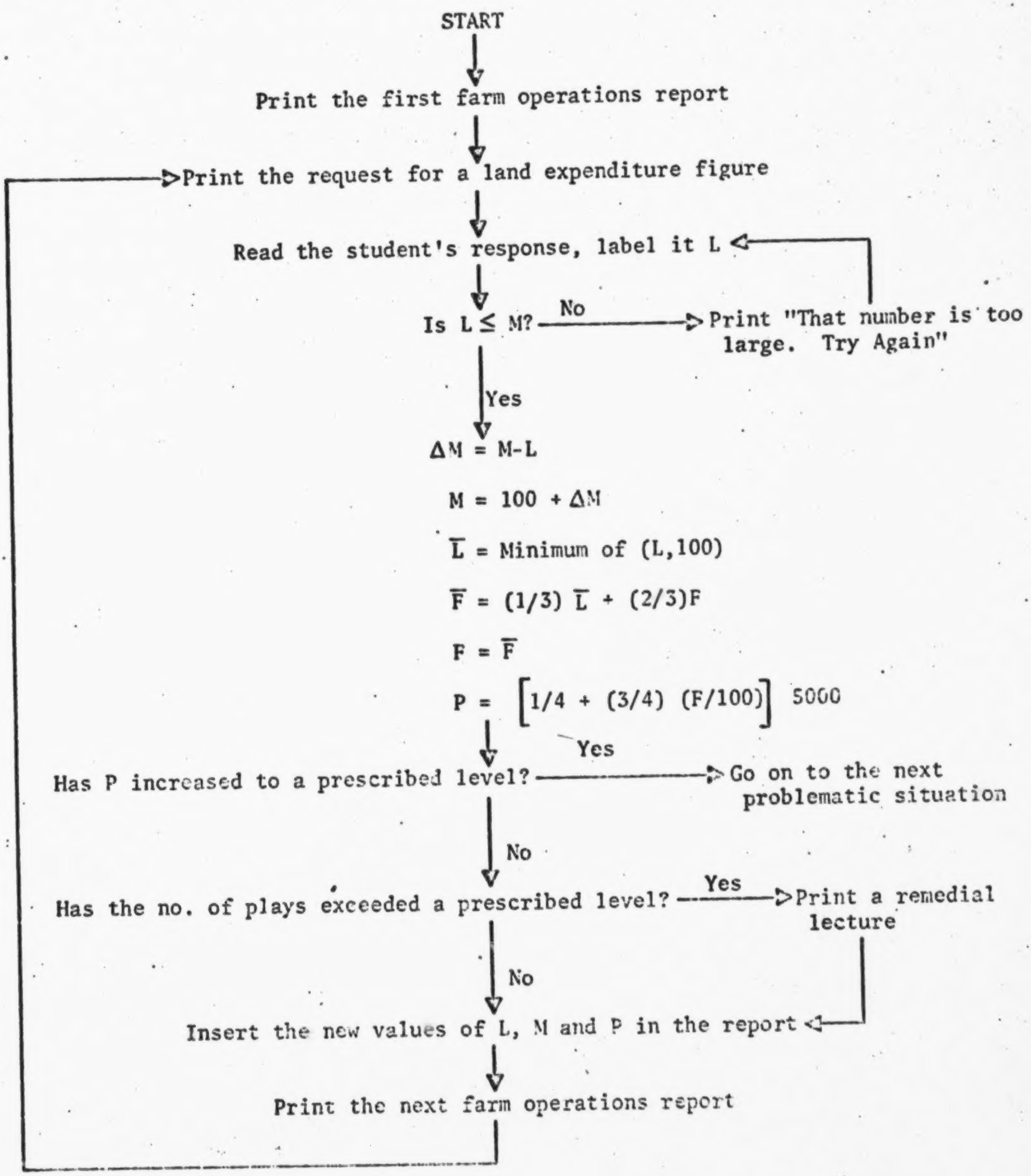

START
Print the first farm operations report
Print the request for a land expenditure figure
Read the student's response, label it L
Is $L \leq M$?
No
Print "That number is too large. Try Again"
Yes
$\Delta M = M-L$
$M = 100 + \Delta M$
$\overline{L}$ = Minimum of (L,100)
$\overline{F} = (1/3)\,\overline{L} + (2/3)F$
$F = \overline{F}$
$P = \left[1/4 + (3/4)\,(F/100)\right] 5000$
Has P increased to a prescribed level?
Yes
Go on to the next problematic situation
No
Has the no. of plays exceeded a prescribed level?
Yes
Print a remedial lecture
No
Insert the new values of L, M and P in the report
Print the next farm operations report

FIGURE 6. FARM OPERATIONS FLOWCHART - LAND EXPENSES

Let E = equipment expenses that are borrowed (leones)

P = production of onions (bushels)

G = a weighted average of past equipment expenses (leones)

Other symbols in the formulas are only used for computational convenience. Initial values for E, P, and G are 400, 6000 and 400 respectively.

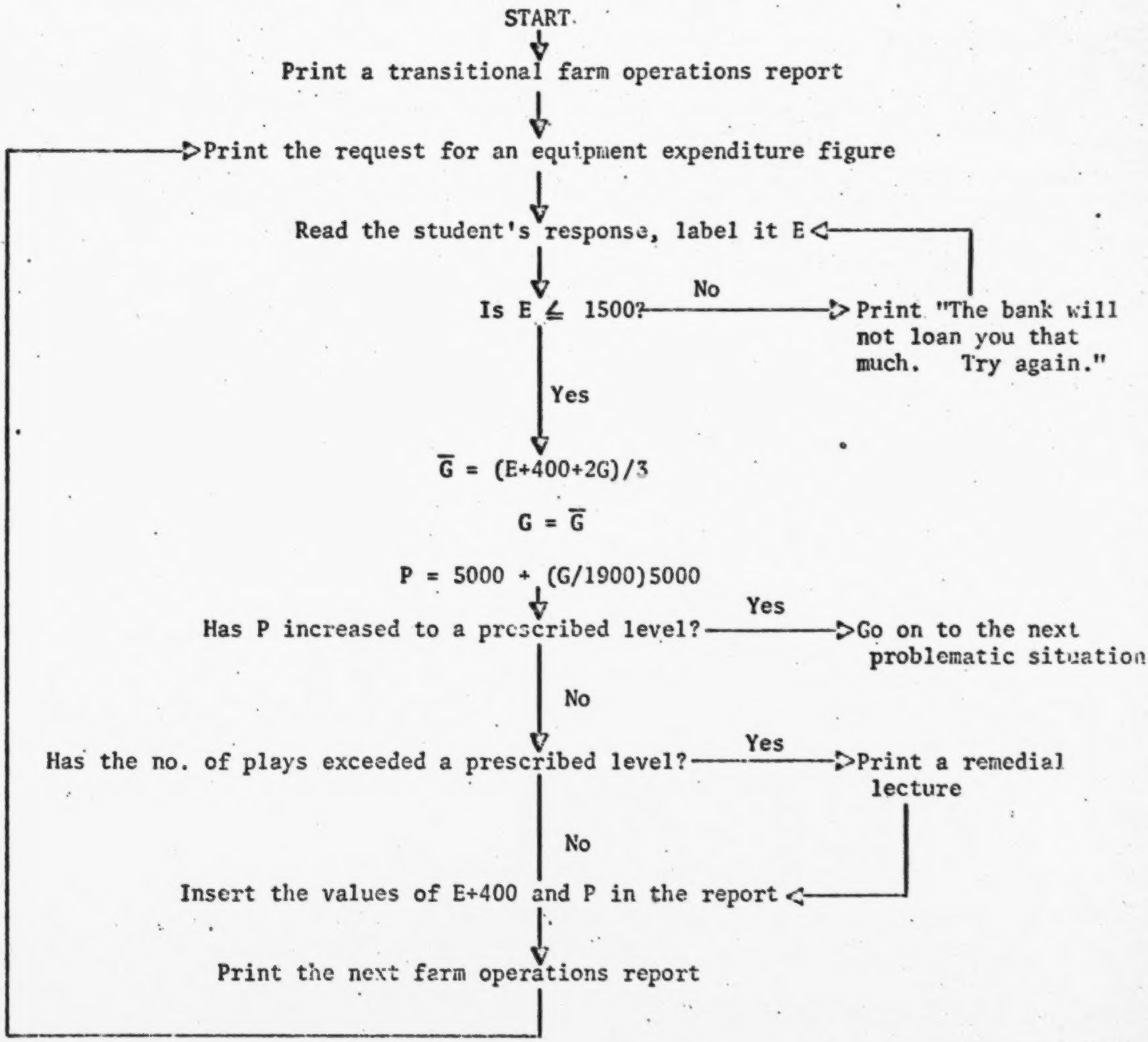

START
Print a transitional farm operations report
Print the request for an equipment expenditure figure
Read the student's response, label it E
Is E $\leq$ 1500?
No
Print "The bank will not loan you that much. Try again."
Yes
$\overline{G} = (E+400+2G)/3$
$G = \overline{G}$
$P = 5000 + (G/1900)5000$
Has P increased to a prescribed level?
Yes
Go on to the next problematic situation
No
Has the no. of plays exceeded a prescribed level?
Yes
Print a remedial lecture
No
Insert the values of E+400 and P in the report
Print the next farm operations report

FIGURE 7. FARM OPERATIONS FLOWCHART - EQUIPMENT EXPENSES

Let N = number of workers on the farm
N = change in the number of workers
W = workers wages (leones)
E = equipment expenses (leones)
L = land expenses (leones)
P = production of onions (bushels)

Other symbols in the formulas are only used for computational convenience. Initial values for N, E, L, and P are 5, 300, 70, and 3300 respectively.

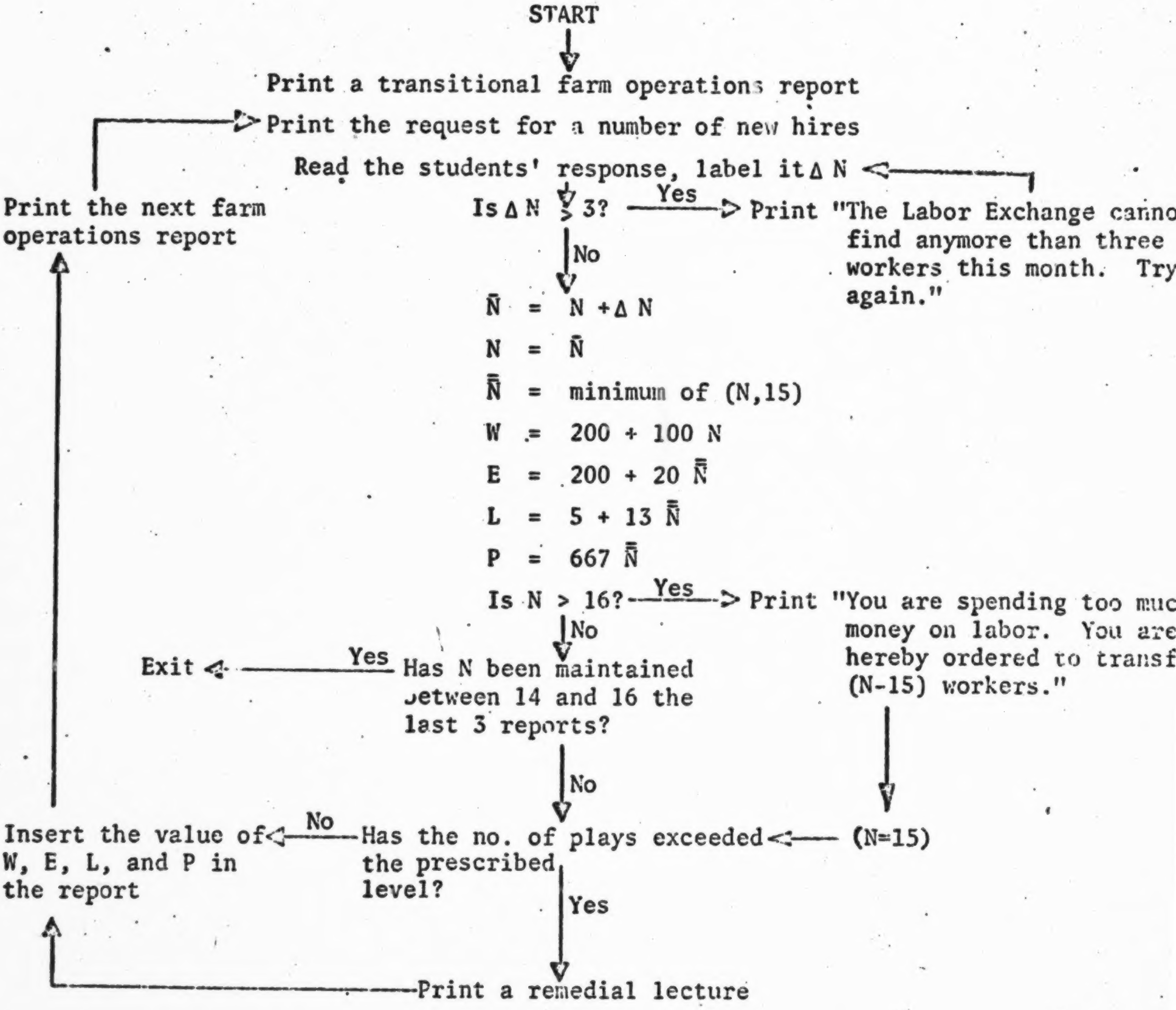

START
Print a transitional farm operations report
Print the request for a number of new hires
Read the students' response, label it Δ N
Is Δ N > 3?
Yes
Print "The Labor Exchange canno
find anymore than three
workers this month. Try
again."
No
N̄ = N + Δ N
N = N̄
N̿ = minimum of (N,15)
W = 200 + 100 N
E = 200 + 20 N̿
L = 5 + 13 N̿
P = 667 N̿
Is N > 16?
Yes
Print "You are spending too muc
money on labor. You are
hereby ordered to transf
(N-15) workers."
(N=15)
No
Has N been maintained between 14 and 16 the last 3 reports?
Yes
Exit
No
Has the no. of plays exceeded the prescribed level?
No
Insert the value of W, E, L, and P in the report
Yes
Print a remedial lecture
Print the next farm operations report

FIGURE 8. FARM OPERATIONS FLOWCHART LABOR EXPENSES

__________Rice Report

The price per ton is__________leones.

The available supply is__________tons.

You have up to_________leones to spend.

How much do you wish to spend?

FIGURE 9. RICE MARKET REPORT

Let L = amount spent to buy rice in one month (leones)

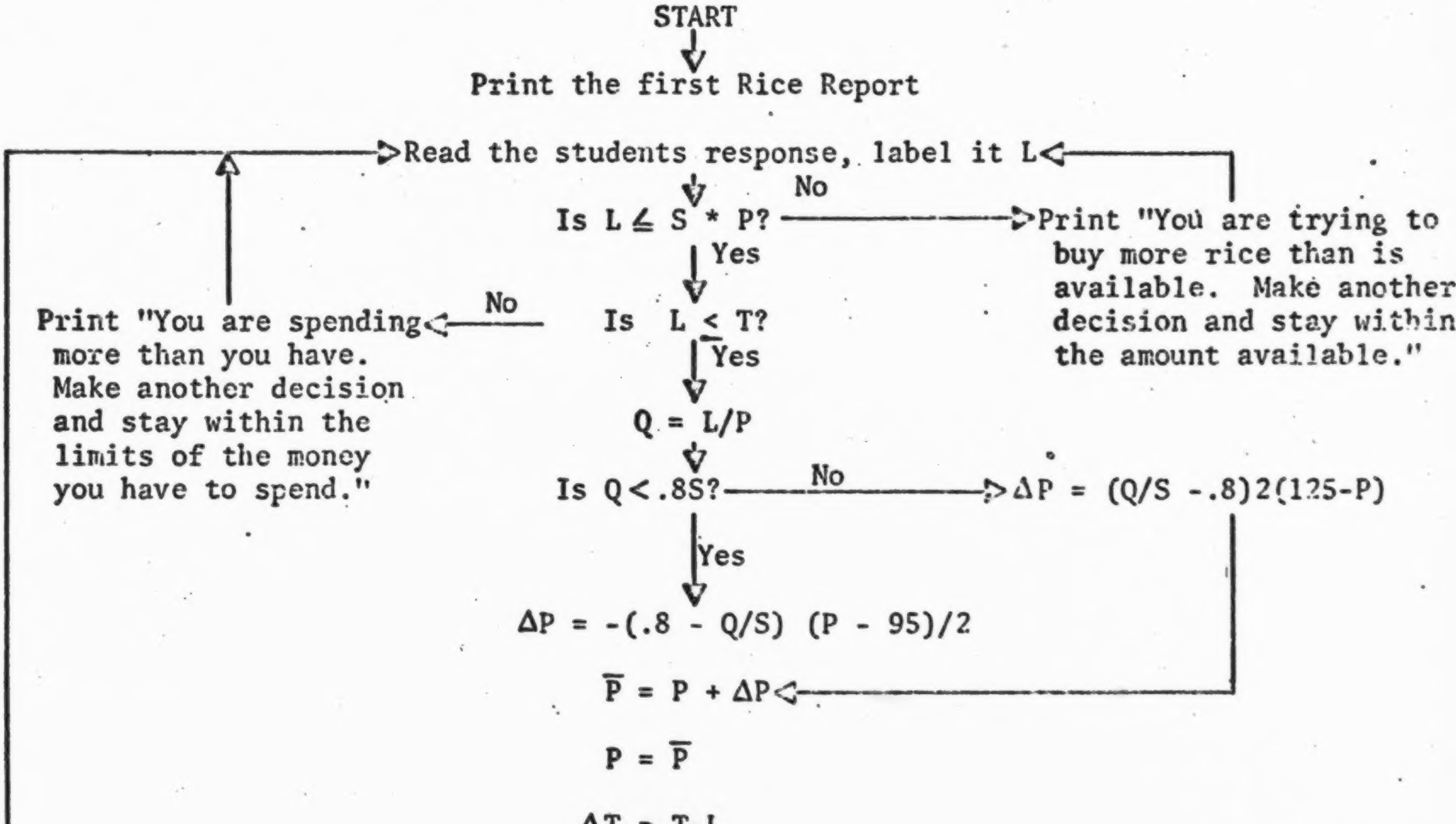
P = the price per ton of rice (leones)

S = the supply of rice (tons)

T = amount available to spend on rice purchases (leones)

Q = amount of rice bought in one month (tons)

Initial values for P, S and T are 110, 5 and 550 respectively.


START
Print the first Rice Report
Read the students response, label it L
Is L ≤ S * P?
No
Print "You are trying to buy more rice than is available. Make another decision and stay within the amount available."
Yes
Is L ≤ T?
No
Print "You are spending more than you have. Make another decision and stay within the limits of the money you have to spend."
Yes
Q = L/P
Is Q < .8S?
No
ΔP = (Q/S - .8)2(125-P)
Yes
ΔP = -(.8 - Q/S) (P - 95)/2
P̄ = P + ΔP
P = P̄
ΔT = T-L
T = 440 + ΔT
S = S(P)
Insert the values of P, S and T in the report
Print the next rice report

$$S(P) = \begin{cases} 1.00 & \text{if } P \leq \\ (P-95)/3 & \text{if } .98 < P < 1 \\ 7.50 & \text{if } 118 \leq P < 1 \\ 7.75 & \text{if } 121 \leq P < 1 \\ 8.00 & \text{if } 124 \leq P \end{cases}$$

FIGURE 10. RICE REPORT GENERATION FLOWCHART

For___________________________, you have orders for______________________carats.

The price per carat is.___________________________leones.

How many carats will you supply?

FIGURE 11. DIAMOND REPORT GENERATION FLOWCHART

Let i = a counter which identifies the month ($i = 1$: January, $i=2$:February, etc.)

S = the amount of diamonds supplied to the market, carats.

D = the amount of diamonds in demand at the market, carats.

P = the market price per carat of diamonds, leones.

i	D_i	P_i
1	2500	18
2	2500	20
3	5000	21
4	6250	21
5	5625	20
6	6875	18
7	5000	22
8	3750	22
9	2500	22
10	2500	18
11	3125	19
12	4375	21

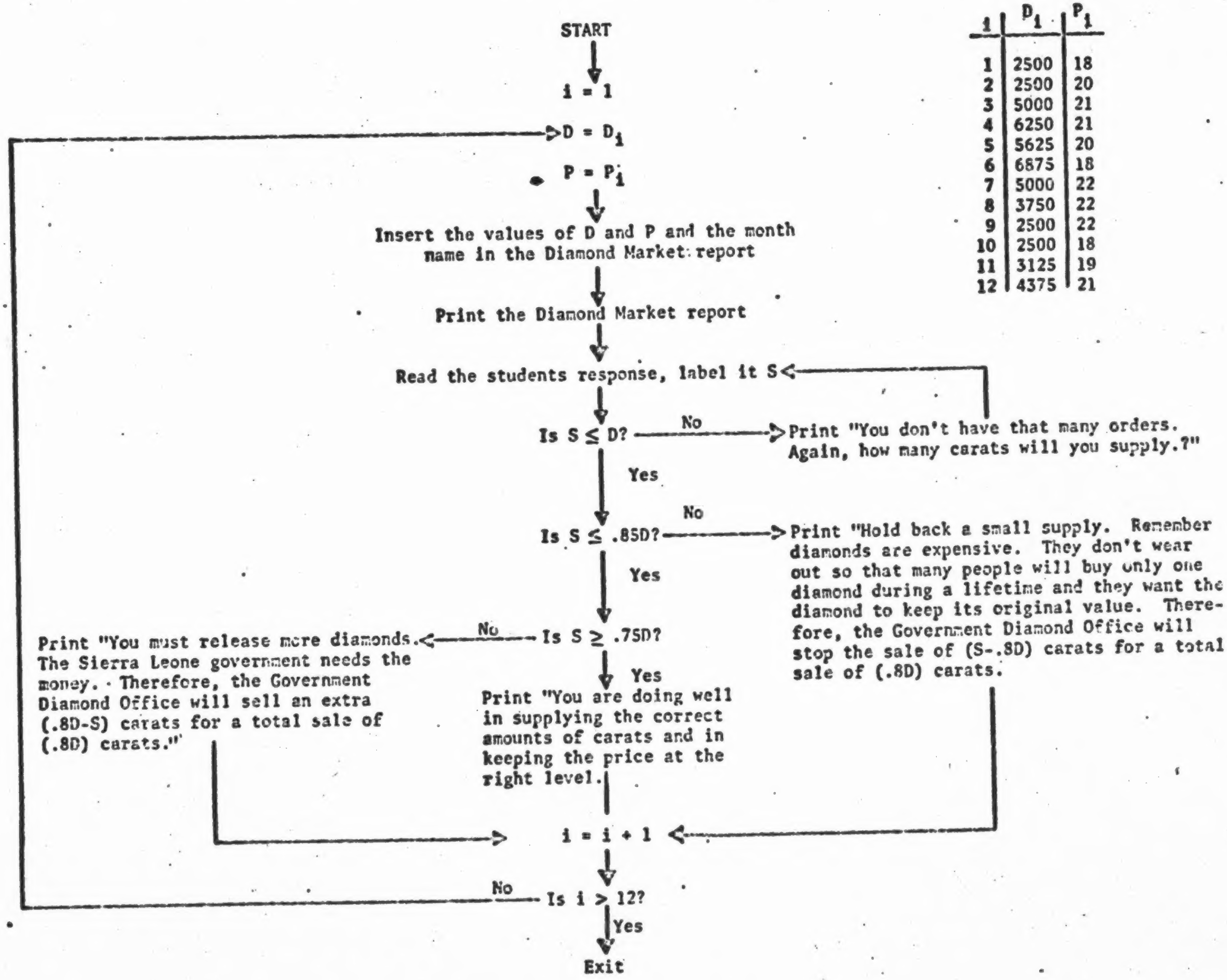

START
i = 1
D = D_i
P = P_i
Insert the values of D and P and the month name in the Diamond Market report
Print the Diamond Market report
Read the students response, label it S
Is S ≤ D?
No
Print "You don't have that many orders. Again, how many carats will you supply.?"
Yes
Is S ≤ .85D?
No
Print "Hold back a small supply. Remember diamonds are expensive. They don't wear out so that many people will buy only one diamond during a lifetime and they want the diamond to keep its original value. Therefore, the Government Diamond Office will stop the sale of (S-.8D) carats for a total sale of (.8D) carats.
Yes
Is S ≥ .75D?
No
Print "You must release more diamonds. The Sierra Leone government needs the money. Therefore, the Government Diamond Office will sell an extra (.8D-S) carats for a total sale of (.8D) carats."
Yes
Print "You are doing well in supplying the correct amounts of carats and in keeping the price at the right level.
i = i + 1
Is i > 12?
No
Yes
Exit

FIGURE 12. DIAMOND REPORT GENERATION FLOWCHART

GNP Report No.____________________

GNP ____________________million leones

Mining Expenses ____________________million leones

Manufacturing Expenses ____________________million leones

Agricultural Expenses ____________________million leones

FIGURE 13. GNP REPORT

Let L = total amount budgeted for government support of mining, manufacturing and agriculture

A = amount of subsidy spent on agricultural sector

M = amount of subsidy spent on mining sector

F = amount of subsidy spent on manufacturing sector

$\bar{A}$ = fractional part of the GNP produced from the agricultural sector

X = fractional part of the total subsidy which is spent in the agricultural sector

Initial values of L, A, M, F, $\bar{A}$ and the GNP are 16, 10, 4, 2, .7 and 80, all in units of millions of leones except for $\bar{A}$ which is a ratio.

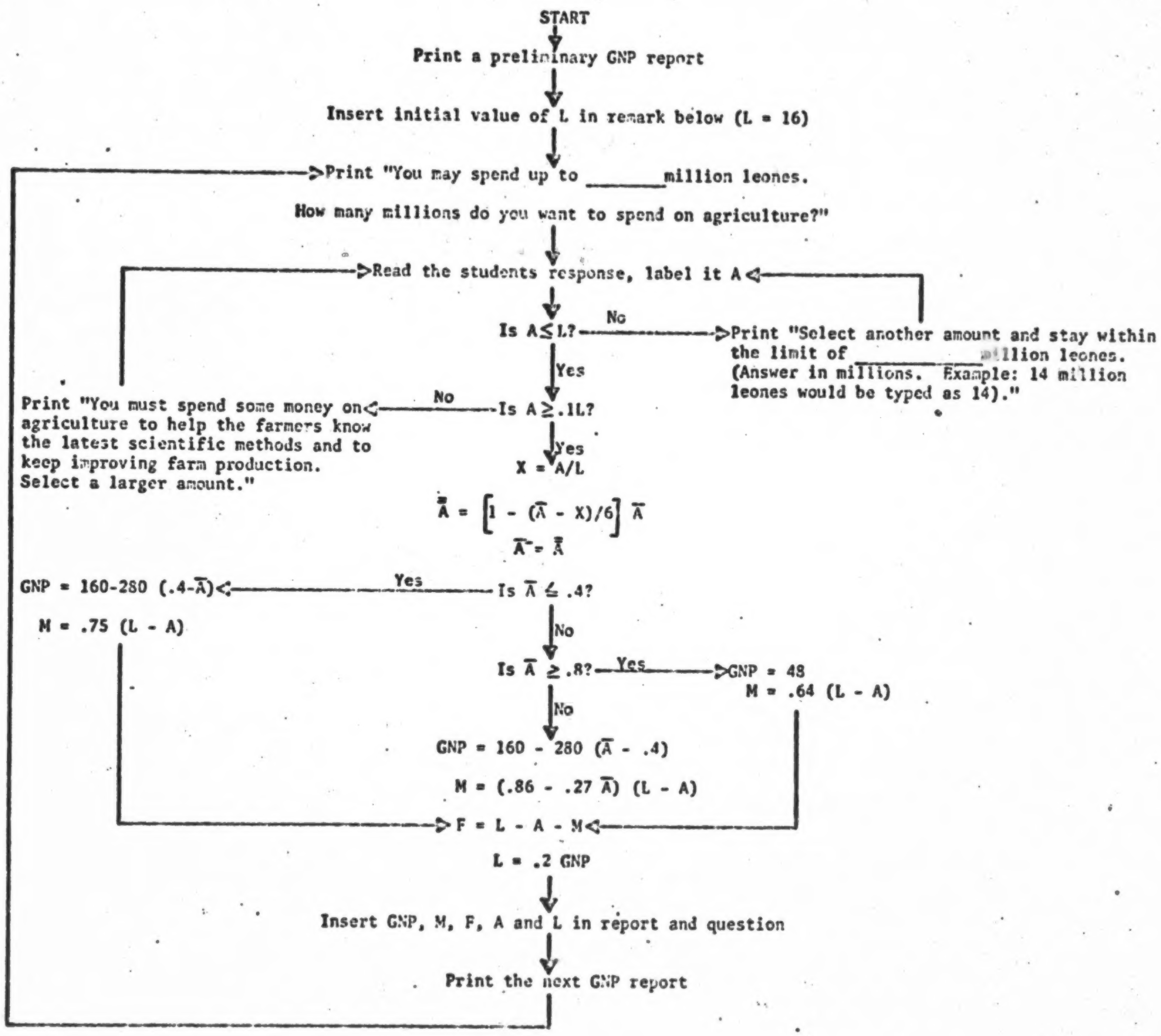

START
Print a preliminary GNP report
Insert initial value of L in remark below (L = 16)
Print "You may spend up to _______ million leones.
How many millions do you want to spend on agriculture?"
Read the students response, label it A
Is A ≤ L?
No
Print "Select another amount and stay within the limit of __________ million leones. (Answer in millions. Example: 14 million leones would be typed as 14)."
Yes
Is A ≥ .1L?
No
Print "You must spend some money on agriculture to help the farmers know the latest scientific methods and to keep improving farm production. Select a larger amount."
Yes
X = A/L
$\bar{\bar{A}} = \left[1 - (\bar{A} - X)/6\right] \bar{A}$
$\bar{A} = \bar{\bar{A}}$
Is $\bar{A}$ ≤ .4?
Yes
GNP = 160-280 (.4-$\bar{A}$)
M = .75 (L - A)
No
Is $\bar{A}$ ≥ .8?
Yes
GNP = 48
M = .64 (L - A)
No
GNP = 160 - 280 ($\bar{A}$ - .4)
M = (.86 - .27 $\bar{A}$) (L - A)
F = L - A - M
L = .2 GNP
Insert GNP, M, F, A and L in report and question
Print the next GNP report

FIGURE 14. GNP REPORT GENERATION FLOWCHART - AGRICULTURE

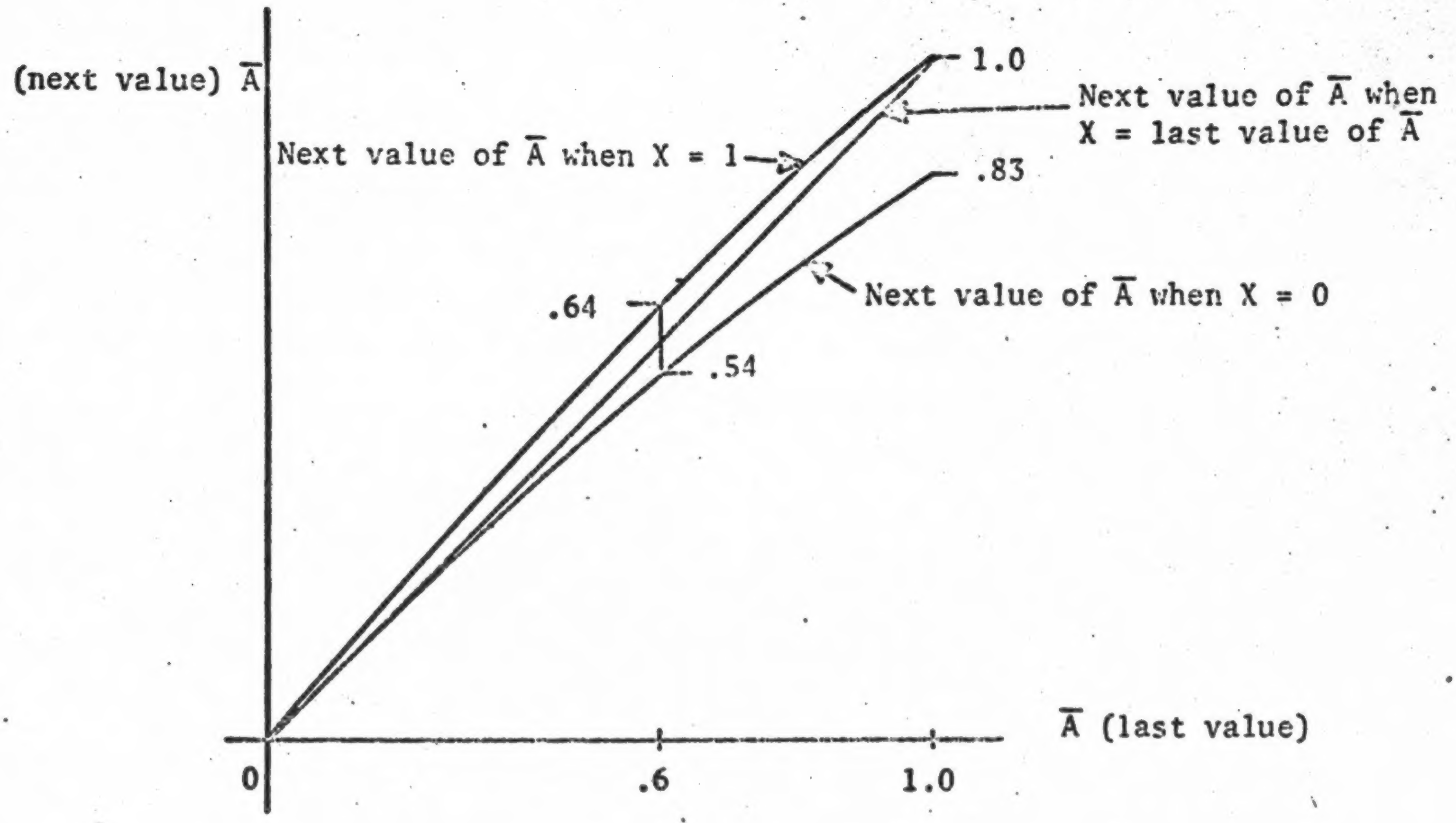


FIGURE 15. NEXT VALUE OF $\overline{A}$ vs. LAST VALUE OF $\overline{A}$ AND X

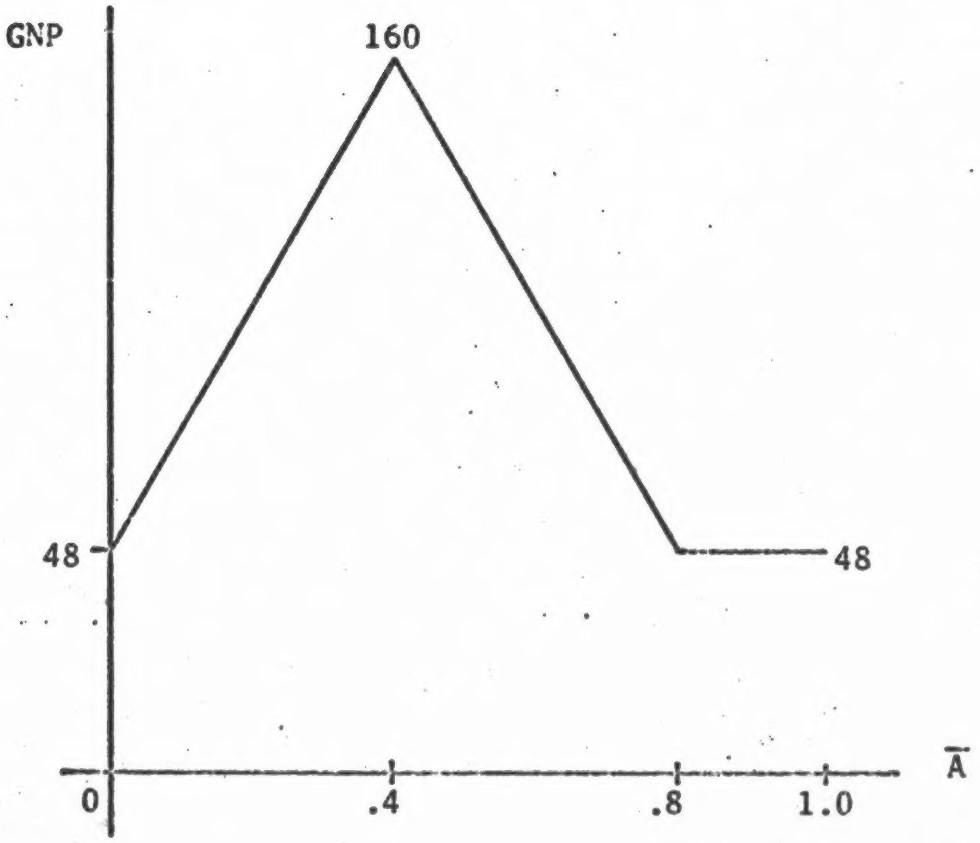


FIGURE 16. GNP vs. $\overline{A}$

Let L = total amount budgeted for government support of mining, manufacturing and agriculture

A = amount of subsidy spent on agricultural sector

M = amount of subsidy spent on mining sector

F = amount of subsidy spent on manufacturing sector

$\overline{M}$ = fractional part of the GNP produced from the mining sector

X = fractional part of the total subsidy which is spent in the mining sector

Initial values of L, A, M, F and GNP are the same as the last values computed during the agricultural subsidy phase. Initial value of $\overline{M}$ is .45.

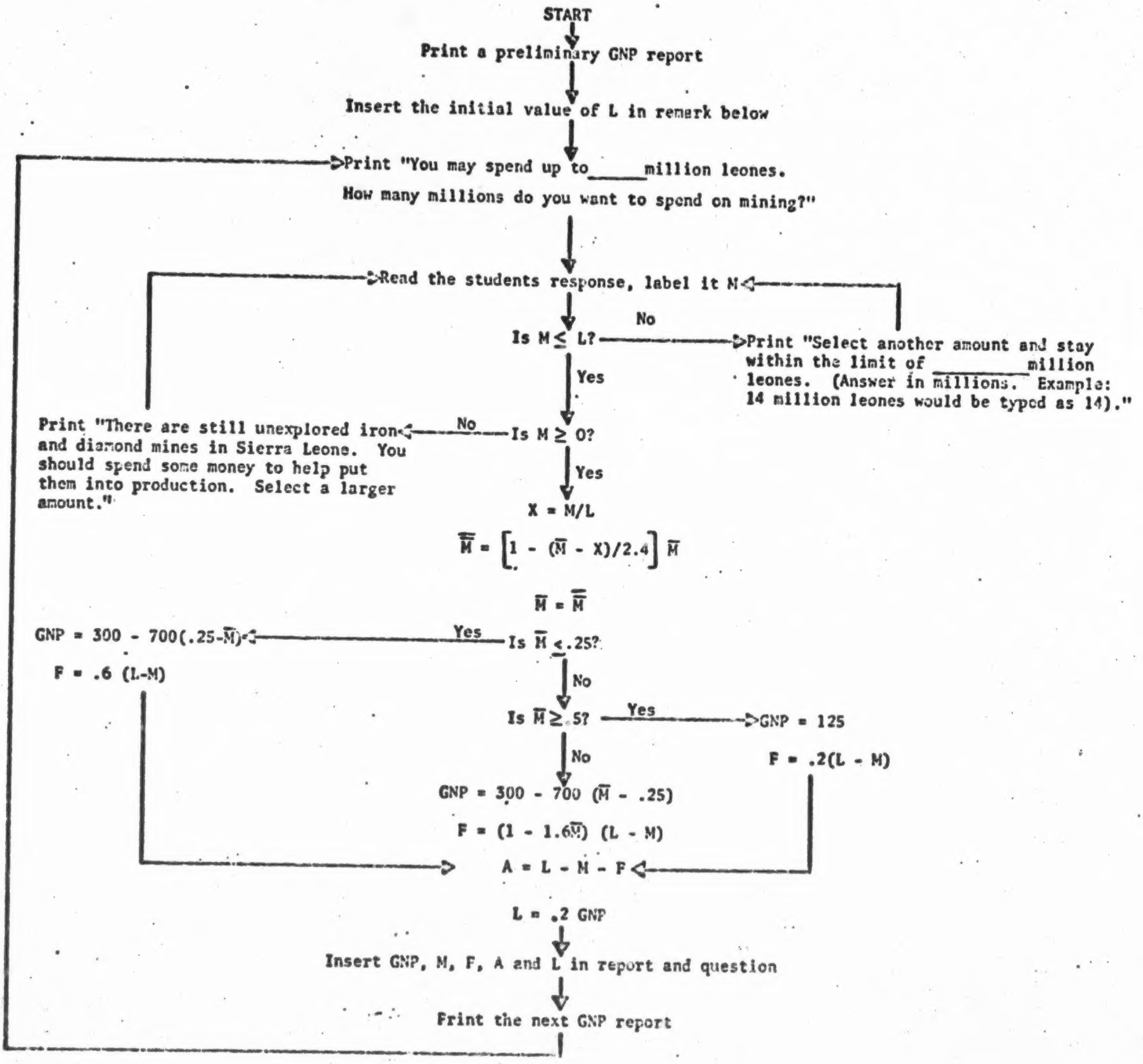

START
Print a preliminary GNP report
Insert the initial value of L in remark below
Print "You may spend up to _____ million leones.
How many millions do you want to spend on mining?"
Read the students response, label it M
Is M ≤ L?
No
Print "Select another amount and stay within the limit of ________ million leones. (Answer in millions. Example: 14 million leones would be typed as 14)."
Yes
Is M ≥ 0?
No
Print "There are still unexplored iron and diamond mines in Sierra Leone. You should spend some money to help put them into production. Select a larger amount."
Yes
X = M/L
$\overline{\overline{M}} = \left[1 - (\overline{M} - X)/2.4\right] \overline{M}$
$\overline{M} = \overline{\overline{M}}$
Is $\overline{M} \leq .25$?
Yes
GNP = 300 - 700(.25-$\overline{M}$)
F = .6 (L-M)
No
Is $\overline{M} \geq .5$?
Yes
GNP = 125
F = .2(L - M)
No
GNP = 300 - 700 ($\overline{M}$ - .25)
F = (1 - 1.6$\overline{M}$) (L - M)
A = L - M - F
L = .2 GNP
Insert GNP, M, F, A and L in report and question
Print the next GNP report

FIGURE 17. GNP REPORT GENERATION FLOWCHART - MINING

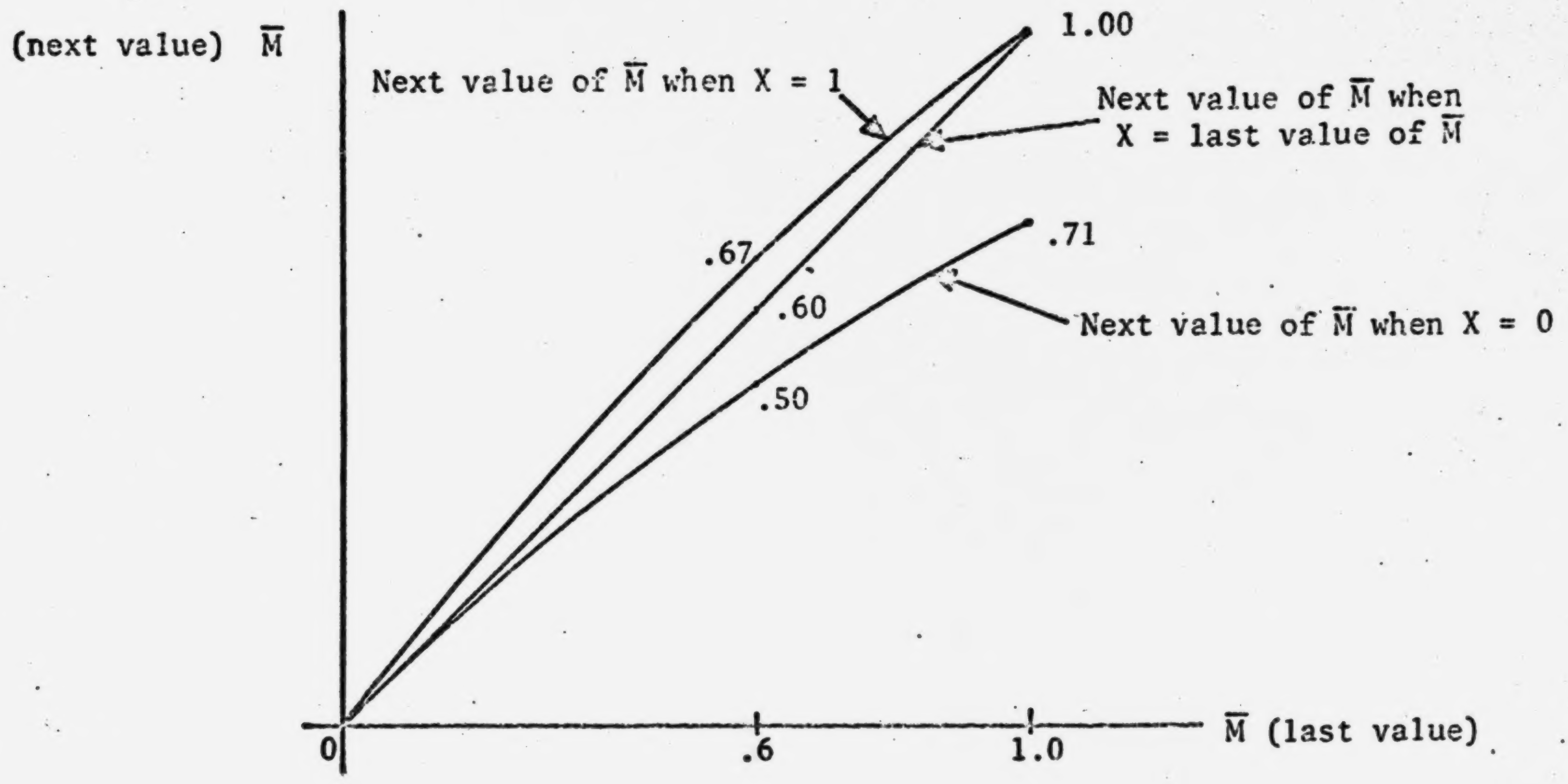


FIGURE 18. NEXT VALUE OF $\overline{M}$ vs. LAST VALUE OF $\overline{M}$ AND X

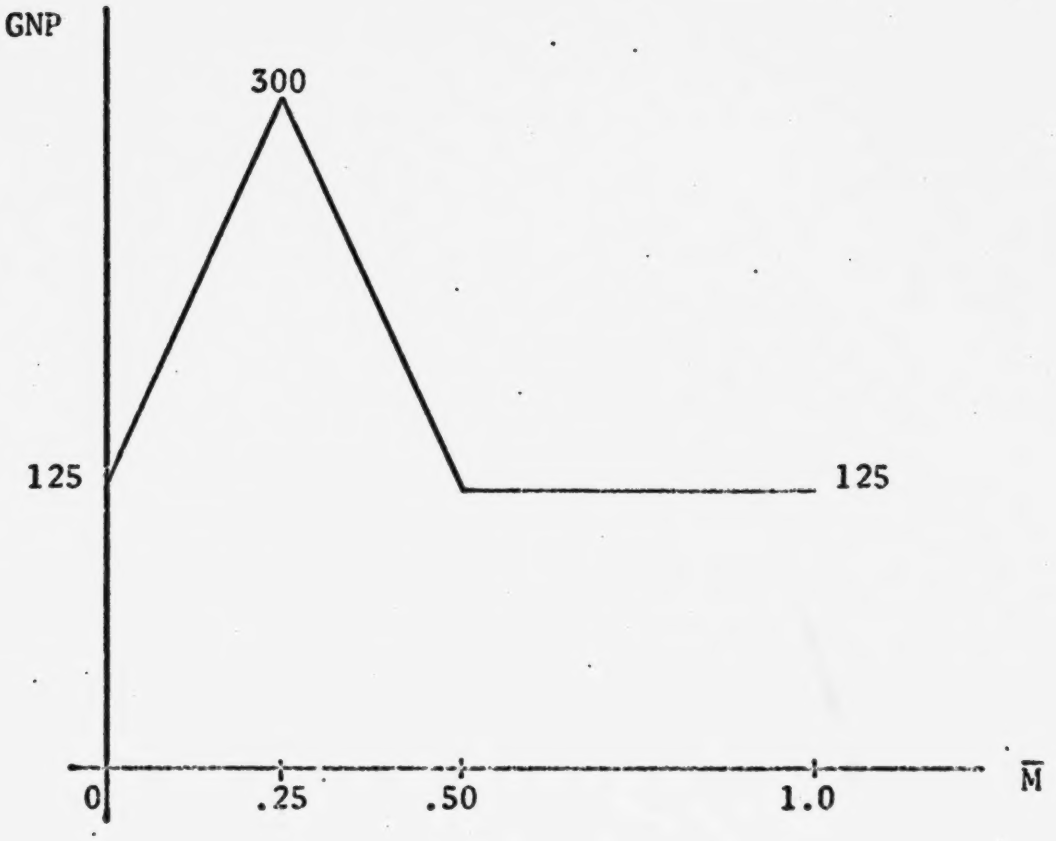


FIGURE 19. GNP vs. $\overline{M}$

Let L = total amount budgeted for government support of mining, manufacturing and agriculture

A = amount of subsidy spent on agricultural sector

M = amount of subsidy spent on mining sector

F = amount of subsidy spent on manufacturing sector

$\overline{F}$ = fractional part of the GNP produced from the manufacturing sector

X = fractional part of the total subsidy which is spent in the manufacturing sector

Initial values of L, A, M, F and GNP are the same as the last values computed during the mining subsidy phase.
Initial value of $\overline{F}$ is .45

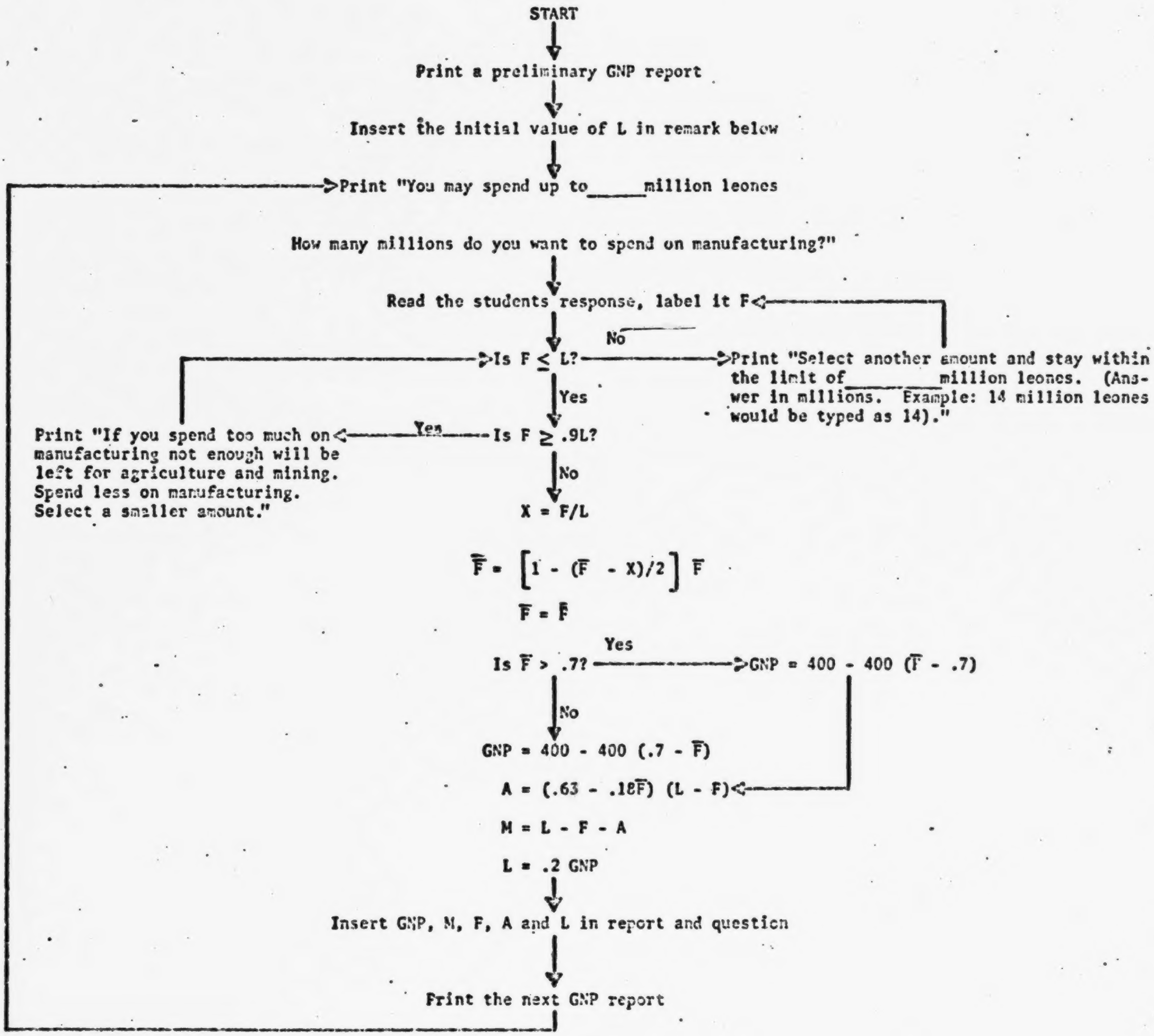

START
Print a preliminary GNP report
Insert the initial value of L in remark below
Print "You may spend up to_____million leones
How many millions do you want to spend on manufacturing?"
Read the students response, label it F
Is F ≤ L?
No
Print "Select another amount and stay within the limit of________million leones. (Answer in millions. Example: 14 million leones would be typed as 14)."
Yes
Is F ≥ .9L?
Yes
Print "If you spend too much on manufacturing not enough will be left for agriculture and mining. Spend less on manufacturing. Select a smaller amount."
No
X = F/L
F̿ = [1 - (F̄ - X)/2] F̄
F̄ = F̿
Is F̄ > .7?
Yes
GNP = 400 - 400 (F̄ - .7)
No
GNP = 400 - 400 (.7 - F̄)
A = (.63 - .18F̄) (L - F)
M = L - F - A
L = .2 GNP
Insert GNP, M, F, A and L in report and question
Print the next GNP report

FIGURE 20. GNP REPORT GENERATION FLOWCHART - MANUFACTURING

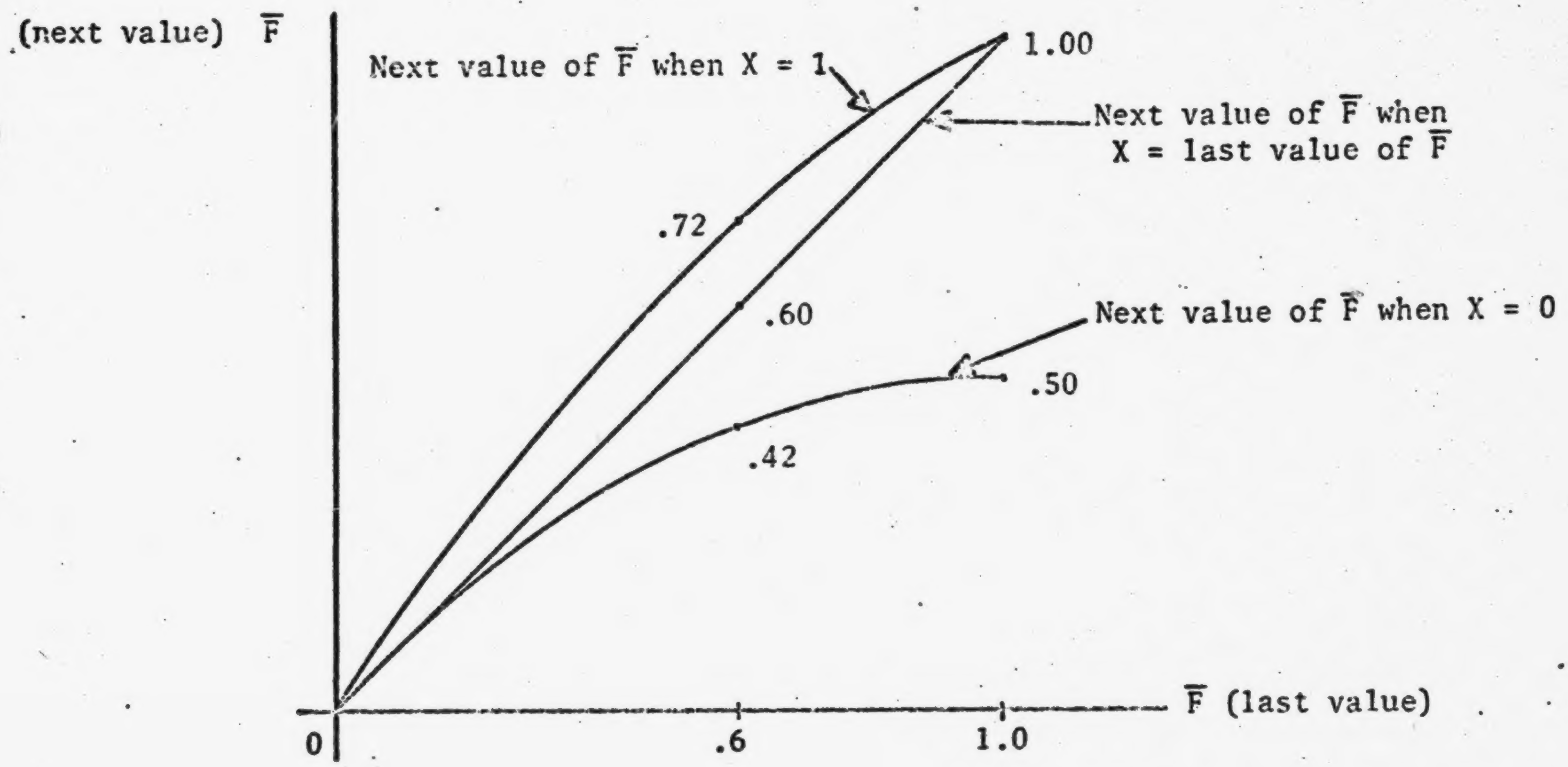


FIGURE 21. NEXT VALUE OF $\overline{F}$ vs. LAST VALUE OF $\overline{F}$ and X

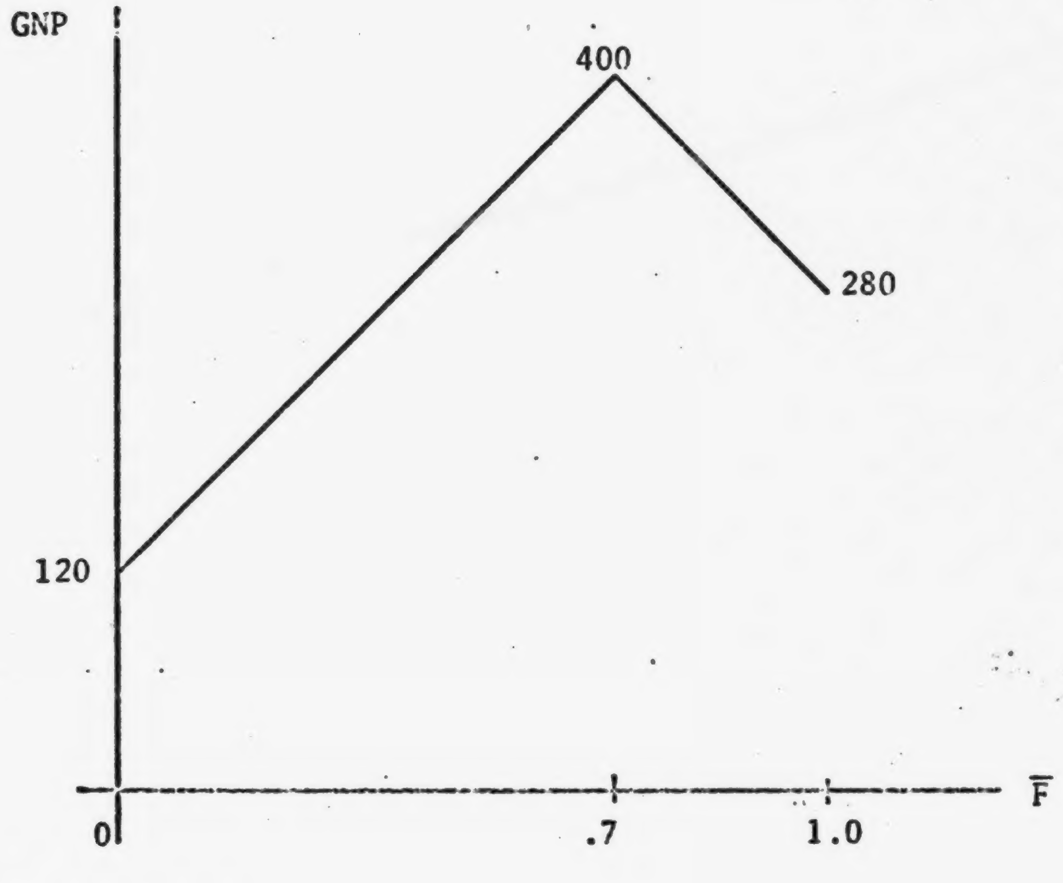


FIGURE 22. GNP vs. $\overline{F}$

Category	N	T-Ave.	D	C	B	A	GRADE
Impossible	2	4.18	0	1	0	1	85
Hard	10	10.65	0	3	1	6	89
Easy	5	9.69	0	1	0	4	94
Other	23	12.78	2	4	7	10	86
All	40	11.40	2	9	8	21	88

FIGURE 23. REPORT CARD

CHAPTER 6: THE FREE ENTERPRISE GAME

Background.--There were two reasons why The Free Enterprise Game setting was selected: (1) it was desired that a completely different type of economic environment be simulated than that utilized in The Sumerian and Sierra Leone Games, and (2) the emphasis was to be placed upon what might be describdd as "practical" economic facts in conjunction with general economic principles.[1]

Description of the Game.--The Free Enterprise Game consists of two phases which, although intended to be played sequentially, may be used as two distinctly separate games. In the first phase of the game (Toy Town) the player assumes the role of the owner and operator of a small toy store. By using the opportunities provided in the simulated environment and by making decisions to combat those factors in the environment which would be detrimental to the operation of his small business, the player should be able to increase the sales and net worth of his store. In the second phase of the game the player assumes the role of the owner of a firm that manufactures surfboards. If this segment of the game is played in conjunction with the first phase, the transition from sales to production is necessitated by market saturation for toys and allied products, which causes the player to diversify his interests to include a manufacturing operation. Or, more simply the costs involved in further increasing the sales of his retail operation are such that his money could be more profitably spent in another endeavor.

The Toy Town phase of the game can take from five to eight hours, depending upon the wisdom of the player's decisions. The Surfboard segment can take from two to four hours. It is intended that players will spend from thirty to forty-five minutes each day playing the game, although a player may stop play at any point and re-start there at a subsequent session.

The entire game is divided into one month segments in simulated future time. At the end of each game month the player learns of his sales, expenses, profit (or loss) for that month and must make decisions

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[1] The Free Enterprise Game was written and programed by Jimmer Leonard, Social Relations Department, The Johns Hopkins University.

(1) that will affect what will happen in the following month and (2) that will influence long-term sales and profits. In addition to monthly reports, the player is presented with annual reports each December. Also, when a player resumes play of a game on a different day, he is presented with a financial report to refresh his memory concerning his current status in the game.

The First Segment

The Toy Town segment is intended to introduce the player to common economic terminology. These terms are intorduced in context so the student can grasp what they mean through his own observations and calculations, rather than through a printed definition. The student is expected to learn through experience and through observing the results of his own decidions in the face of problematic situations presented to him.

Details of Monthly Play.--Each month he is faced with the decision of how to allocate his receipts from sales among his own wages, replacement of merchandise sold during the month, his monthly expenses, savings, and various opportunities for expansion that are presented. These opportunities are of the following types: (1) investment in equipment that might increase sales, such as a delivery truck, shopping carts, and display cases; (2) purchase of new types of merchandise not previously handled in his store such as various sporting goods, hi-fi equipment, and records; and (3) agreement to shoulder the burden of higher monthly expenses in the future for such things as newspaper advertising, a sales clerk, and parking lot rental.

In addition, there are other increases in monthly expenses that do not affect sales. These fall into two categories: (1) those which the player has no control over (tax increases, increased charges for electricity if an air conditioning system was installed, etc.) and (2) those in which the player makes a decision as to whether to incur a voluntary expenditure (liability insurance, property insurance, etc.)

Finally, there are "random" occurrences introduced. One type is the random expense, which is only for a single month and is intended to teach the player the necessity for having an amount of money in savings for such contingencies. Examples of these include vandalism (before the opportunity to purchase property insurance was presented) and window breakage (after the player has decided whether to purchase insurance). There are also randomly presented opportunities to engage in special one-month-only sales campaigns. Many of these are tied to displays concerning holidays, such as sponsoring a fireworks show for the Fourth-of-July.

Results of the Player's Decisions.--An effort has been made to assure that "yes" is not necessarily the correct answer to a question of the variety "Do you want to...?" Purchase of air conditioning and a delivery truck will result in higher sales; however, profits will decline due to expenses for electricity and truck maintenance. Liability insurance pays for itself in the light of subsequent losses, but the property insurance does not. The subroutines involving purchase of record listening booths and shopping carts are constructed to encourage the player to purchase---over a period of time---too many of these items, so as to illustrate the principle of diminishing returns. In the purchase of new kinds of merchandise, the increase in monthly sales will depend upon the seasonal applicability of the item. (The simulated environment is geographically taken to be the northern part of the United States.) Thus, the purchase by the player of a large stock of sleds or skiis in July will result in a very limited sales increase. Even the replacement of merchandise sold during a game month is not optimally accomplished by the formula of relying on "replace the amount that was sold." Particularly, the player who replaces only the amount sold will find that, if he decides to engage in some new advertising campaign, the demand created by these ads will be such that his stock of merchandise the following month will be insufficient to satisfy his potential sales.

In this segment of the game a player can place his savings in a "savings bank." If the player chooses to do so, he will annually receive interest of 4%. In contrast with this situation, in the Surfboard segment his money is in a checking account which provides no interest. Furthermore, he would have received a loan from the bank in order to buy machines, for which he would be paying 6%.

Economic Concepts.--Some of the concepts the student should learn through playing the game are: (1) the difference between goods and services and public and private services; (2) the relationship between risk and return; (3) the necessity of re-investment of capital to promulgate growth; (4) the concept of diminishing returns; and (5) uses and usefulness of taxes, insurance, and savings.

Terminology is also introduced which the player will, we hope, learn to comprehend: profit, loss, assets, liabilities, sales, and other terms.

Although the vehicle of a "toy store" was chosen in the simulation for the first segment of the game, it was intended that the economic principles presented would be transferrable to any retail operation primarily, and to other situations in a secondary way.

The Second Segment

After completing play of The Toy Town part of the game, the player turns over the day-to-day operation of his store to a manager and devotes his time to the manufacture and sale of plastic surfboards.

The player controls production by changing the number of workers and machines. His monthly sales will depend upon the season and the selling price he asks.

Monthly Reports.--Like the first segment of The Free Enterprise game, this part is divided into game-months. Each month a report is printed informing the player of his sales, expenses and profit. A sample report follows (student responses are underlines). (See FIGURE 24).

Players' Decisions.--Each month, the player must decide for what amount he will sell his surfboards during the following month. The lower the price, the larger the number that will be sold; in the summer season, a greater number of surfboards will be bought for a given price than in the winter season. The seasonal demand curves are of different shapes.

Also, the player is given the opportunity to change the number of machine operators each month and thus change production. If money is available, one or more additional presses may be purchased.

In addition to machine operators, there are workers who pack the finished surfboards (the number being a function of production) and those who ship the surfboards sold (the number a function of sales). For $30,000. the player may purchase a machine to replace 20 packers. It is left up to the player whether to purchase such machines in order to reduce monthly expenses or whether to invest in more presses in order to expand production.

Facets of the Model.--Periodically, the demand curve for surfboards shifts upwards, although retaining its shape. This provides an incentive for expansion of production. This happens only several times during a game-year, so as to allow the player to grasp---given a fixed demand curve---the inverse relationship between selling price and number sold (i.e., price and demand).

By increasing the number of machine operators, the production of surfboards increases. However, this is not a linear increase; for a fixed number of machines the increase in production for each additional worker added begins to decrease after a certain point is reached.

Additional expenses are introduced on a random basis in the game. These expenses are for one month only, and do not affect the cost of labor and raw materials, or the "fixed" expenses.

Potentially, the Surfboard segment of the Free Enterprise game is more complicated than the Toy Town part. The major complicating factors are the seasonal changes and the presence of an inventory. No single strategy is necessarily the correct one. A player may choose, for instance, to drastically limit both production and sales in the winter months, or he may produce

FIGURE 24, SAMPLE PRINTOUT FROM SURFBOARD GAME

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                         FEBRUARY 28, 1972

BEGINNING INVENTORY (516) + MONTH'S PRODUCTION (1,500) = 2,016 SURFBOARDS AVAILABLE TO SELL DURING MONTH

THIS MONTH'S SALES = 1,726 BOARDS AT $10.50 PER BOARD                               $  18,123.

INVENTORY REMAINING AT END OF MONTH = 290

   RAW MATERIALS:  1,500 BOARDS AT $4 PER BOARD            $6,000.
   LABOR COSTS:    30 WORKERS AT $200 PER WORKER           $6,000.
   FIXED EXPENSES (INCLUDING $275 INTEREST ON LOAN)        $2,275.
   TOTAL MONTH'S EXPENSES:                                                          $  14,275.

PROFIT (SALES - EXPENSES):   $  5,565.  (LAST MONTH)       $3,848.  (THIS MONTH)

CHECKING ACCOUNT BALANCE:    $ 10,565.  (PREVIOUS)        $14,413.  (CURRENT)

YOU MAY BUY ONE PRESS FOR $20,000.  DO YOU WANT TO?.

YES

          NUMBER OF MACHINE OPERATORS                  NUMBER OF BOARDS PRODUCED

   LAST MONTH           12        (  5 MACHINES  )            1,600
   THIS MONTH           10        (  5 MACHINES  )            1,500

DO YOU WISH TO HIRE OR FIRE ANY MACHINE OPERATORS?

HIRE 4 MORE

                 PRICE PER SURFBOARD         NUMBER SOLD

   LAST MONTH           $10.00                  1,984
   THIS MONTH           $10.50                  1,726

HOW MUCH DO YOU WISH TO CHARGE FOR EACH SURFBOARD NEXT MONTH?

10.75

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at full capacity in the winter to build up an inventory for the summer.

The game ends under any one of three conditions: (1) the player is not able to pay the $20,000 in principal to the bank (after a one year extension), (2) the player's checking account becomes overdrawn by $20,000, or (3) the net worth of the business exceeds $1,000,000, which constitutes a successful termination of the game.

The following are some of the concepts emphasized in this segment of the game:

(1) The division of labor increases efficiency.

(2) Different efficiency and output occur under varying worker/machine ratios.

(3) An inverse relationship exists, for most products, between the price charged for a product and the quantity demanded by consumers.

(4) The point at which profit is maximized depends upon a complex relationship between demand/price and cost of production. Thus, maximum profit may occur at a point different from that of most efficient production.

(5) Demand for a product is not fixed in time; seasonal variation, as well as a change in overall demand, occurs.

(6) Automation may result in a savings in labor expenses. However, the money spent for automated equipment may be more advantageously spent to increase production facilities.

(7) Certain fixed expenses exist which remain the same no matter how many units are sold or manufactured.

Testing of the Free Enterprise Game.--The game has been played through by four students on an informal basis. Three of the students have been from the Special Education Department of BOCES. The time required to play the entire game varied from 15 to 30 hours.

Since the original programing of the Free Enterprise Game it has been extensively revised and is at this writing being revised again. Visual displays in the form of 35 mm slides taken of drawings are being produced for delivery by carousel projectors.

CHAPTER 7: FACILITIES AND TECHNICAL PROCEDURES

Equipment

Computer Systems.--The Sumerian Game and the Sierra Leone Game were played on three IBM 1050 terminals, two equipped with modified carousel projectors and the third with an experimental random access film strip projector. The terminals located at the BOCES Research Center were connected by Dataphone to a special-purpose 7090 Computer, which was under supervision of a Time Sharing Monitor system (TSM) at IBM'S East Coast Advanced Systems Development Division in Yorktown Heights, New York.

The coding language for the first two games was Fortran Assembly Program (FAP) with a few additional control cards for file loading purposes. The Sumerian Game used about 15,000 lines of instructions and approximately 37,000 memory places in the TSM computer system.

The Free Enterprise Game has been programed in Autocoder for delivery by a 1401 computer at Johns Hopkins University to terminals at the BOCES Research Center.

Visual Displays.--During each game about seventy-five pictures were displayed by the modified carousel projector and the random access film strip projector. In the case of the Sumerian Game the pictures were made by photographing a series of dioramas built by Otto Schmidt of the BOCES staff. In the Sierra Leone Game a variety of photographs, graphs, and maps were made into slides by Mr. Schmidt.

Procedures at the Terminals

Functioning of the Terminals.--Play of the instructional games is effected by the interaction of a student with the computing system via the terminal. The terminal keyboard-printer unit, much like a typewriter in appearance, is the principal device used for communicating game messages to the student, and consequent student responses. The keyboard is normally locked. When in this state, the computer-programed-game is sending messages to the student; the keyboard is unlocked only following the transmission of a message explicitly requesting the student to respond. After the request is sent, the keyboard is unlocked, a green "Proceed" light flashes on, and the computer-programed game waits for the response. Only when the student has completed his response by striking a special End-of-Message key, does the game program go on to other procedures.

Student Responses.--The student, in composing responses, must use the typewriter-like keyboard and know the special keystroke with which he signals the end of his response. He must also be able to understand the messages sent to him, especially those requesting a response, and know how to express himself conventionally.

In actual operation, the terminals are brought to a ready-to-play state by the terminal supervisor. The student may play the game for a while and either complete it or stop play, to continue at another time. In either case, the terminal supervisor performs a simple shutdown procedure.

Terminal Start Up.--The terminal start-up procedure requires:

1. The power must be turned on at the terminal.
2. Using the Dataphone* associated with the terminal, the appropriate number at the computer center must be dialed.
3. After the telephone connection is made, the computing system unlocks the keyboard to allow an identification message to be sent.
4. With identification properly made, the keyboard again unlocks to allow a service-requesting message to be sent.
5. A first service request is to "select" (get out of the computing system library and make ready to use) the appropriate game program.
6. The next service request is to "run" the selected game. This request to "run" causes subsequent terminal activity to be directed by the selected game program.

Terminal Shutdown.--The terminal shutdown procedure requires:

1. The student stops play at a convenient place in the game (perhaps at the end).
2. The terminal supervisor, activating a special key, causes the game program to become inactive and returns

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* Trade Mark of American Telephone and Telegraph Company

control of subsequent terminal activity to the general computing system program.

3. The student's copy of the game program (containing a record of his play) is returned to the system's library.

4. The system is signaled that no more service is required, after which the telephone-line connection is broken automatically.

5. Power is then turned off at the terminal by the teacher-monitor.

Common Design Features of the First Two Games

A number of game design features are common to both games. In reviewing the designs, it is clear that some features used in only one game might also have been used in the other. Several different techniques that either were or might have been used in common for both games and perhaps usuable in a larger class of games are described in the following paragraphs.

Red and Black Ribbon.--All typed information very naturally falls into two categories: that typed by the student, and that typed (printed) by the computer. Rapid review is enhanced by differentiating between the two. Since the volume of material typed by the student is relatively small, a design rule was selected as follows: Student type-ins will appear in red; computer type-outs, in black.

Student Response Syntax.--Some of the messages printed at the terminal by the computer are in the form of questions which require some response from the student. In making a response the student must express himself in the exact form specified by the game designers. In specific sections of the games, responses might be acceptable if, for example, they are only single-digit or single-word type-ins. This kind of constraint is determined by the game authors depending upon the context of the response. A more basic set of syntactical rules applicable to all responses is listed below:

- A response is made up of a sequence of typewriter keystrokes, the last, a special one, signaling an end-of-message.

- Words and numbers may be constructed using a special alphabet: the normal alphabet a to z, the digits 0 to 9, and the special characters: @ # $, . + - and /.

- The distinction between upper and lower case letters in a response is ignored.

- Either the space or tab keystroke in a response indicates a separation between words or numbers.

- The carriage return or end-of-message keystroke signals that the response is ended.

- A backspace keystroke in a response indicates that the preceding keystroke is to be deleted from the response.

- Other keystrokes, not explicitly mentioned above, used in composing a response are simply ignored.

- A sequence of characters which starts with a digit, a decimal point, a plus or minus sign and extends to a non-digital character, other than a period or a comma, will be treated as a number.

- The following examples of number responses illustrate the variety of forms that are acceptable:

  1234 1,234,000 1.234 .0034 +4.5 -67.8

Report Card Recording.--A general report-card form (Figure 23) was established to accept a recording of a grade (A, B, C or D) in each of four categories of questions: impossible, hard, easy, other. The format also includes recordings of the student's time-of-response in these same four categories. A copy of a report card may be requested by the instructor at any time after the student has commenced play; normally, it is printed at the terminal immediately after the student has finished a section of his play. The report card data in Figure 23 shows that a total of 40 questions were put to the student, the average time to respond was 11.4 seconds, 2 answers earned a grade of D, 9 a grade of C, 8 a grade of B, and 21 a grade of A. The overall grade was 88 based on weighting the scores: 50 for a D, 70 for a C, 85 for a B, and 100 for an A.

In the Sumerian and Sierra Leone games the report card was not used to measure a student's play. Only in scattered instances were student responses evaluated and entered into the report card. Those measurements that were made and displayed in printed report card form demonstrated the feasibility of this type of record keeping.

Exceptional Conditions Handling.--Two exceptional conditions that may occur and be detected by the computing system are: (1) If during the time the green Proceed light is on no key is struck within a period of approximately 30 seconds, the keyboard is locked and the Proceed light is turned off, (2) If during a transmission of information to or from the terminal a bit of information is either lost or picked up from some noise source, the transmission is terminated, and the normal sequence is interrupted. The procedure for correcting (1) is simply to return the carriage, advance the paper, and reinitiate the read by turning the green Proceed light on again. Condition (2) is handled in two ways: if the condition is encountered while sending a message to the terminal, the carriage is returned, "Machine Error" is printed in red, the carriage is returned again, and the last printed unit of information, usually a sentence or short paragraph, is reprinted. If the condition is encountered while composing a message at the terminal, the carriage is returned. "Please retype reply" is printed, the carriage returns again, and the Proceed signal light turns on.

Restart Procedures.--A complete play of either of the two games -- spanned a number of days. Picking up play of a game after an overnight pause was very simply done by selecting from a system memory device a copy of the previous day's program. This "saved" program contained records which identified the student, his place in the play of the game, and a summarization of the effects of his past decisions.

PART III: EXPERIMENTAL PROCEDURES AND RESULTS

Brief description.--In order to assess the results of the games, an experiment was set up along these lines. From October 1965 to March 1966, twenty-six sixth-grade students from the Mohansic School in Yorktown Heights, New York, played the two games on three terminals at the Center for Educational Services and Research of BOCES. Meanwhile a control class of equal ability studied about the economics of life in Sumer and Sierra Leone under the direction of a talented teacher using ingenious but "conventional" methods.

The effectiveness of the whole experiment was measured by several different techniques. One was to observe the students carefully and interview them after they finished playing the games. Another was to compare their pre- and posttest scores on specially prepared tests of economic understandings, and a third was a depth interview technique designed to probe for understanding of economic concepts on the part of selected pupils.

Before and after the experimental use of the terminals all students in both control and experimental classes were pretested with the "Test of Economic Principles Based on Ancient Sumer" and the "Test of Economic Principles Based on Sierra Leone" prepared for the project.

CHAPTER 8: EXPERIMENTAL METHOD

Selection and Comparison of Subjects.--The four sixth-grade classes at the Mohansic School in Yorktown Heights, New York, are chosen in such a way that each class is similar to the others in respect to the ability of students and number of students in each class. Since we wanted an intact class for a control group taught by a willing and capable teacher, we chose the class of Ronald Lundberg as a control. Another teacher in the sixth grade, Mrs. Harriet Forsythe, agreed to help us by scheduling her pupils for instruction on the computer system, so her class was designated as the experimental group.

In order to make sure that the two groups were approximately equal in ability, a comparison was made between the scores of the groups on the California Test of Mental Ability and on the Reading Section of the Iowa Test of Basic Skills.

Since there was a finding of no significant difference between the two groups on these tests, it was concluded that the two groups were enough alike to provide a basis for comparison of experimental versus control methods. Later pretesting with the homemade tests of economic principles confirmed this belief.

Techniques Used in the Control Class.--Mr. Lundberg, teacher of the control class, received instruction from the authors of the two games that he was to teach certain principles of economics (see descriptions of the games) and acquaint his class with some of the conditions of life in ancient Sumer and modern Sierra Leone. He was given some pictures and printed materials about those two places.

For three weeks during the fall of 1965 he used a technique essentially as follows to teach about the economics of ancient Sumer.

The class was divided into three groups of equal ability. In two of the groups the children were assigned roles as members of an imaginary Sumerian community such as farmers, bakers, traders. In each group there was a priest-king who led a discussion. For three weeks, one-hour a day, these groups discussed the problems of running the economy in ancient Sumer. The third group became planners and writers, preparing materials and procedures for the other two groups.

The economics of Sierra Leone was taught in a somewhat more conventional fashion through the use of slides on Sierra Leone, some lectures, class discussion, and map activities. Some reading materials were available. This instruction continued approximately one hour a day for three weeks.

During the rest of the year there was occasional reference to Sierra Leone when the students were discussing social and economic conditions in other countries.

Before and after Mr. Lundberg started each three-week unit he administered the appropriate test of economic understanding.

Scheduling of Students at the Terminals.--The Center for Educational Services and Research had at the time of the experiment three IBM 1050 terminals. The twenty-six pupils in the experimental group were transported from their school, about a half a mile away, to the Center, three at a time, to play the games. Each group worked for about ninety minutes and then was replaced by another group of three. The following day the same groups were brought back to continue where they had left off. This procedure continued until a pupil finished both games and was replaced by a student who had not played a game. Some students started with the Sumerian Game and then played the Sierra Leone Game. Others started with the Sierra Leone Game and, when they had finished it, played the Sumerian Game. Since there was considerable variation in the time each student took to complete a game, the scheduling became quite complex, with some students finishing up one game while others were starting a new one.

As soon as each pupil arrived at the Center for the first time to play the Sumerian Game, he was given the pretest and watched an introductory sequence of slides and tapes describing his future role as priest-king of Lagash. He was then seated at the terminal and shown how to operate it. The terminal supervisor, Mrs. Christine Hartz, signed on the program each time and saved the student's record of play when he finished. She remained available in case of system difficulty or confusion on the part of the student. Usually it was not necessary for her to intervene in the play.

While a student was playing the games, the terminal supervisor kept a record of any unusual occurrences. When a student finished a game, she interviewed him and administered the posttest of economic principles for the game he had finished.

The Tests of Economic Principles.--There were no standardized tests of economics suitable for the purposes of this experiment, so special tests were constructed, one for each game. It was intended that these tests would be refined through an item analysis, but we could not find a population of sixth graders who knew enough about economics to score above the guessing level. Subsequent analysis with students who have gone through the units of instruction reveals that there are some poor items on the tests. Even so the tests have Kuder-Richardson reliabilities of .806 for the test on Sumer and .769 for the Sierra Leone test.

The tests are included as Appendix A to this report. It will be noted that most of the items are multiple choice, true-false, or simple completion questions. There is no time limit to the tests. Most students finished in half an hour.

Observational Techniques.--While the pupils were at the terminals in the Center for Educational Services and Research, Mrs. Hartz, the Terminal Supervisor, observed their behavior and made notes on any unusual or significant activities on their part.

Interviews.--When each student finished a game Mrs. Hartz administered the post-test and interviewed the students, using a simple check list of questions about the interest which the pupils felt in playing the games. (See Appendix B).

Time Checks.--The terminal supervisor also kept records of the number of minutes that each pupil spent seated at a terminal.

Depth Interviews.--The tests of economic principles did not provide enough information about the depth of understanding which each subject had of the economic concepts. A depth-interview procedure was then devised to explore the possibilities of probing for greater detail on student concepts than the objective test was able to provide.

Five students from the control group and five from the experimental group were brought back to the Center for interviews by an interviewer with experience in motivational research.[1] Structured questions based on twenty principles of economics from the Sierra Leone game were posed to the students and their responses recorded on tape. The student was then led into more detailed analysis of each issue by a probing technique. Afterwards the tapes were played back by the interviewer and a rating assigned to each pupil for each principle discussed.

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[1] Mrs. Gertrude Eckelt conducted the depth interviews and analyzed the tapes. (See Appendix C).

CHAPTER 9: FINDINGS AND INTERPRETATIONS

Analysis of Objectives.--The objectives listed in PART I could be transposed into these questions:

1. Is it possible to program complex economics games for a time-shared computer and have them run for some hours without intervention by instructional personnel?

2. How effective is this mode of instruction; i.e., do students learn more economics? do they retain what they have learned longer? do they learn with greater understanding, or faster than by other means of instruction?

3. Is there any saving of instructional time when the computer-based games are used?

4. What is the relationship between intelligence and learning by the simulation techniques employed and between reading ability and gain? Do the students who finish faster learn more?

5. Do students appear to enjoy playing instructional games on the computer?

6. In what ways do computer-based games meet certain theoretical criteria for individualization of instruction?

7. Is it feasible for games developed under the grant to be used in other places?

Findings

1. Practical Operation

After a few initial program errors were cleared, the games ran smoothly. Each student worked independently of other pupils and received no help from the terminal supervisor except in these cases:

a. When he had misplayed the game to the extent that the message "please call the teacher" appeared. In this case the student was started over again and required to read aloud the instructions.

b. Whenever any program errors or system failures occurred.

c. Whenever he failed entirely to understand a question, assignment, or paragraph within the game. These occasions were rare.

d. When, in one particular instance, the terminal supervisor read aloud the bulk of the printout to one of the students with very low reading ability.

As distinct from the act of manipulating the typewriter terminal, the gaming part of the program presented no real problem to the students. The rules of procedure were simple and explicit enough so that they had no trouble playing the game. Whatever rules there are in these games are explained or made evident as the instruction progresses.

With the exception of the two students who had very low reading ability, the sixth graders seemed to have no trouble in reading the printout or following instructions. They were able to learn some principles and understandings about economics at the relatively simple level at which theywere presented.

2. Effectiveness as Method of Learning

The pretesting and posttesting produced the results shown in TABLE 6.

TABLE 6

MEAN SCORES, PRE- AND POSTTEST, TWO GAMES

	Sumerian Game		Sierra Leone Game	
	Control	Experimental	Control	Experimental
Pretest	15.8	17.0	14.4	14.1
Posttest	19.3	24.2	26.9	24.9
Gain	3.5	7.2	12.5	10.8

Control group: N-24 Experimentals: N-26

The difference between the control and experimental groups on the Sumerian Game, 3.7, is significant at the .01 level of confidence favoring the experimentals. The difference between the two groups on the Sierra Leone Game was 1.7, non-significant, but favoring the controls.

a. Gain on Test of Economic Principles.--It was found that in the Sumerian Game the experimental group gained a significantly greater amount from pretest to posttest than the control group. This difference in gain was significant at the 1% level of confidence. In the Sierra Leone game the control group scored slightly but not significantly better than the experimental group.

It appears from our testing that we should not claim that for the purpose of teaching principles of economics, the computer-game technique is clearly superior to classroom instruction. It does seem, however, that the experimental method is at least as effective, to judge by the measurement which we employed. The issue is clouded somewhat by the fact that the tests constructed for this experiment are less than perfect, having Kuder-Richardson reliabilities of .806 and .769 respectively. The issue is also confused by the fact that we found a significant change in favor of the experimental group on one game and the opposite, but non-significant, difference on the other game.

b. Retention.--Table 7 gives gains and losses on the retention tests, which were administered in June of 1966.

TABLE 7

RETENTION OF ECONOMIC INFORMATION AND UNDERSTANDING, CONTROL AND EXPERIMENTAL GROUPS

Average gain or loss, possttest to retention test

	Sumer Tests	Sierra Leone Tests
Control group	+3.2	-1.5
Experimental group	- .3	-3.1

According to these test results the control group forgot less than the experimental group between the time the posttests were given during the Winter of 1965-6 and the Spring of 1966, as far as the Sierra Leone game is concerned, and actually did better on the retention test of economic understandings dealing with Sumer than on the earlier posttest, while the experimental group suffered a slight loss in retention.

We cannot explain why the control group obtained higher scores on the Sumer retention test than on the posttest.

A fuller analysis of the retention findings is given in Appendix

c. Concepts best Taught by Game.--Tables 8 and 9 supply figures which are a measure of the degree to which learning, represented by the test items, was a fulfillment of the expectation of the experimental hypothesis in the two games. The last column in each table is labeled "A Pertinence Index," which compares the gain of the experimental group with the gain of the control group on each item in the tests. The higher the figure is, the more the experimental group learned (whatever is represented by the item) than the control group. If it is negative, this means that the control group got more out of the items represented than the experimental group.

Individual test items were studied with reference to the Pertinence Index as a means of identifying those types of behaviors (as represented by the test items) which are enhanced by the simulation or experimental procedures.

The Pertinence Index was invented by Francis G. Cornell to help identify concepts which were most effectively taught by the game.

Analysis of Test Items for the Sumerian Game Using the Pertinence Index

An analysis of the items with a low or high Pertinence Index for the Sumerian test tells us only this:

1.) Some topics on which the experimentals did well were stressed or repeated in the game. Conversely one or two negatively scored topics were infrequently or not explicitly brought into the game.

2.) Some concepts were made vivid in the game as in the case of the need for saving emphasized by the introduction of frequent disasters.

3.) The actual involvement of pupils in making decisions in the game and the results of their decisions (which became apparent in the immediate feedback and were reinforced by long range feedback) should account in part for the success of the experimental group on some items.

Analysis of Questions and Answers for the Sierra Leone Game Using the Pertinence Index

The questions having the lowest Pertinence Index for the Sierra Leone games were Numbers 1, 4, 7, 14, 17, and 20. Of these--

1) Questions 7, 17, 20, and Matching 1 are basically factual.

2) Questions 1, 4, 14, and Diagram 2 require understanding and interpreting concepts.

The questions having the highest Pertinence Index were 23, 24, 25, Diagrams 1, 3, and 4, and Completion Items 2, 5, 7, and 8.

1) The first six of these required interpretation of graphs and diagrams.

2) None of the above is a factual question.

Although further analysis of test items by means of the Pertinence Index could be made, some interesting disclosures have already appeared. For one thing, in the Sierra Leone Game, the experimental group appear to have surpassed their control counterparts the most on those test items based on graphical and diagrammatical presentations in the game. They appear to have done less well on certain factual items in interpreting four specific concepts.

TABLE 8

COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS IN GAIN IN PERCENT PASSING TEST ITEMS, SUMERIAN GAME

Test item	Experimental group			Control group			Pertinence index*
	Percent passing		Gain	Percent passing		Gain	
	Pre-test	Post-test		Pre-test	Post-test		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	58	65	7	46	83	37	-30
2	73	92	19	83	63	-20	39
3	23	35	12	21	13	- 8	20
4	58	65	7	71	29	-42	49
5	31	15	-16	33	25	- 8	- 8
6	31	85	54	29	58	29	25
7	77	73	- 4	71	63	- 8	4
8	46	77	31	33	33	0	31
9	50	58	8	21	33	12	- 4
10	31	54	23	63	50	-13	36
11	62	62	0	42	54	12	-12
12	54	54	0	67	50	-17	17
13	39	58	19	42	46	4	15
14	35	69	34	42	67	25	9
15	81	92	11	92	96	4	7
16	77	73	- 4	42	58	16	-20
17	58	69	11	63	75	12	- 1
18	73	77	4	67	58	- 9	13
19	77	65	-12	46	63	17	-29
20	39	54	15	29	50	21	- 6
21	50	50	0	46	50	4	- 4
22	39	39	0	29	38	9	- 9
23	62	81	19	54	75	21	- 2
24	50	81	31	38	71	33	- 2
25	39	65	26	21	38	17	9
26	0	23	23	0	29	29	- 6
27	42	69	27	13	38	25	2
28	77	96	19	79	96	17	2
29	58	92	34	58	88	30	4
30	54	69	15	50	58	8	7
31	46	81	35	54	67	13	22
32	35	62	27	17	33	16	11
33	4	50	46	13	21	8	38
34	19	58	39	13	21	8	31
35	4	46	42	8	21	13	29
36	50	96	46	58	88	30	16
37	8	73	65	17	29	12	53

* Column 4 minus column 7

TABLE 9

COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS IN GAIN IN PERCENT PASSING TEST ITEMS, SIERRA LEONE GAME

Test item	Experimental Group			Control Group			Pertinence index*
	Percent passing		Gain	Percent passing		Gain	
	Pre-test	Post-test		Pre-test	Post-test		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	27	50	23	17	92	75	- 52
2	39	65	26	38	63	25	1
3	27	62	35	29	79	50	- 15
4	19	15	- 4	17	54	37	- 41
5	58	96	38	33	100	67	- 29
6	23	92	69	25	96	71	- 2
7	19	62	43	8	88	80	- 37
8	15	23	8	21	13	- 8	16
9	35	54	19	21	67	46	- 27
10	42	58	16	42	71	29	- 13
11	31	58	27	71	88	17	10
12	46	42	- 4	46	58	12	- 16
13	27	23	- 4	13	21	8	- 12
14	50	19	- 31	38	46	8	- 39
15	31	46	15	50	46	- 4	19
16	35	35	0	25	38	13	- 13
17	65	73	8	50	88	38	- 30
18	46	100	54	33	96	63	- 9
19	19	39	20	25	88	63	- 43
20	35	62	27	38	92	54	- 27
21	50	62	12	42	63	21	- 9
22	42	54	12	42	42	0	12
23	23	46	23	46	46	0	23
24	23	31	8	42	8	- 34	42
25	4	23	19	21	8	- 13	32

* Column 4 minus column 7

TABLE 9 (CONTINUED)

Test item	Experimental Group			Control Group			Pertinence index*
	Percent passing		Gain	Percent passing		Gain	
	Pre-test	Post-test		Pre-test	Post-test		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	54	42	- 12	54	71	17	- 29
2	35	58	23	42	79	37	- 14
3	19	65	46	17	88	71	- 25
4	15	31	16	8	46	38	- 22
5	15	46	31	13	75	62	- 31
1	46	62	16	63	42	- 21	37
2	54	31	- 23	29	38	9	- 32
3	31	62	31	50	38	- 12	43
4	31	65	34	42	50	8	26
5	35	65	30	46	63	17	13
1	0	81	81	0	92	92	- 11
2	23	69	46	46	58	12	34
3	19	92	73	13	71	58	15
4	23	77	54	4	79	75	- 21
5	19	62	43	8	17	9	34
6	65	85	20	58	92	34	- 14
7	42	81	39	38	42	4	35
8	50	89	39	79	75	- 4	43
9	0	19	19	4	17	13	6
10	0	23	23	0	17	17	6

* Column 4 minus column 7

Conclusion: The game method was not noteworthy for teaching facts. The games taught some concepts well, others poorly. The games taught well when graphs and and diagrams were to be interpreted.

d. Quality of Concepts Measured by Depth Interview.--The number of students interviewed was too small to give reliable results, but the technique appears to be productive, though time-consuming, and has indicated to us that somehow we have missed opportunities in the construction of the games to provide explanations and opportunities to practice conscious transfer of understanding from one problem to another.

Details on the Depth Interview are given in Appendix C.

3. Time

The teacher of the control class spent approximately an hour a day for three weeks on the subject matter of each of the two games, or approximately thirty hours *in toto*.

In the experimental setting the average pupil time on the Sumerian Game was 10 hours and 15 minutes with a range from 6 hours and 40 minutes to 14 hours and 5 minutes. The average time on the Sierra Leone Game was 5 hours and 5 minutes with a range from 3 hours and 55 minutes to 8 hours and 0 minutes. The combined average then is about fifteen and a half hours to complete both games.

Not counting time taken for transportation or down time on the computer system, the experimental students spent about half as much time on the terminals as the control group spent in class studying similar materials.

4. Relationships Between Learning and Factors of Individual Differences

a. Correlations

TABLE 10

CORRELATION BETWEEN GAIN IN SUMER AND SIERRA LEONE TESTS AND FOUR FACTORS, EXPERIMENTAL GROUP ONLY (N=23)

	Gain	
Correlation with	Sumer Test	Sierra Leone Test
1) I.Q.	.388	.546**
2) Reading Score	.228	.417*
3) Time on Computer	- .199	- .374
4) Pretest Score	- .161	- .492*

** Significant at one percent level
* Significant at five percent level

1) This finding makes it pretty clear that the more intelligent students gained more from pretest to posttest than the less intelligent students, even though there is a ceiling on the test which prevents the best students from displaying the whole range of their talents. This should not be interpreted to mean that the less intelligent students are not learning at all, since one correlation is fairly low.

2) It is scarcely surprising that there is a correlation between reading ability and improvement of test score. What is surprising is that this correlation is not higher, since the bulk of the communication from computer to student is by means of a typed printout. If an audio system were available, students of low reading ability would be under less handicap. As was mentioned before, in the case of a very poor reader in the experimental group, the terminal supervisor was required to read the printout aloud and this enabled her to get through the game even though the amount of gain from pretest to posttest was almost nil.

3) Apparently the students who spent the least time at the computer made the greatest gains. This is possibly because the students who were spending the least time on the computer were those who were, generally speaking, the better students, so they were also learning more. It should be pointed out that the average in time on the computer is not closely related to gain. In other words some of the students who take a long time on the computer are also students who are learning well.

4) The negative relationship between the gain on the test and pretest score would seem at first thought to indicate that students well-informed at the beginning of the experiment made less gain than the less well-informed. It is more likely, however, that the negative correlation results from the ceiling on the test which prevents the already well-informed students from moving farther along the criterion measure; in other words, the ones who did poorly on the pretest gained more because they had more to learn as measured by the test.

b. Graphical Representations

FIGURES 25, 26 and 27 illustrate graphically the low correlation between selected pairs of variables measured in the course of play on the Sumerian Game.

As shown in FIGURE 25, there is almost no correlation between intelligence and the time which pupils in the experimental class needed to complete the game. In other words, some of the bright students were among the slowest and some were among the fastest in game play.

FIGURE 26 indicates that there is no strong relationship between speed at the game and success in learning about economics.

FIGURE 27 represents a low correlation of the order of .388 between intelligence and gain on the test. Some of the most intelligent students apparently made the least improvement, while their less-bright classmates were showing greater improvement in some cases.

The implications of these comparisons for grouping are rather interesting. There is certainly the suggestion here that if students are grouped on the basis of intelligence test scores, they may not be homogeneous in respect to the speed or success with which they go through gaming instruction on the computer. Conversely, the notion is conceivable that pupils who would otherwise be ranked low among their peers in terms of intelligence or speed of performance may do rather well in a game situation.

5. Motivation

In regard to the interest which students had in the game, we found that almost without exception the pupils said they enjoyed playing these economic games on the computer, and this high interest was maintained throughout the two games, which lasted an average of 15 hours in total.

At the conclusion of the game playing, fourteen students were interviewed concerning their attitudes toward the games. A summary of their responses is given in Appendix B.

Some of the more important reactions were these:

1. All students enjoyed playing the games.
2. Some found the Sumerian Game repetitious. (The game has since been shortened and otherwise revised.)
3. The majority would like to spend half a day learning through a computer system rather than all day or not at all.
4. The typing required was generally not a source of trouble.
5. Most pupils reported enjoying the role playing.
6. Most liked the slides; some felt they were enjoyable but not essential.
7. Most thought they learned a lot from the games.
8. Of the two games, Sumer was more popular, even though some of those preferring it thought the grain planting routine repetitious.
9. The majority would prefer working in a soundproof booth.

We conclude that the games are a positive motivational technique, but we do not know how much beyond 15 hours of play they would continue to be found interesting. We also acknowledge the probable influence of a strong Hawthorne effect.

6. Theoretical Individualization

Individualized instruction may be said to exist in a procedural sense when provision can be and is made for the nine kinds of variation in methods listed in PART I.

Generally speaking the computer games which we have developed provide variability in six out of the nine categories theoretically specified. It should be noted, however, that other kinds of variation could easily be introduced by using alternate program loops to vary the difficulty of the problems or alter the sequence of events.

a. Change of Content

In the system used for the experiment it is possible to change from one game to another merely by signing off one game and signing on the other with a few instructions to the computer

b. Variation in Scope

The game segments are variable in length depending on the success students have in solving economic problems.

c. Change of Pace

Change of pace is provided. Students solving problems easily progress through the game more rapidly.

d. Alteration of Sequence

Generally speaking there is no provision for altering the sequence within which problems are presented.

e. Variation in Difficulty

There is no provision for varying the difficulty of the principal problems. There is some provision for progressive explanation, but not much.

f. Switching of Presentation Modes

Two modes are used - typewriter printout and slide display, with the great bulk of the learning dependent on the printout.

g. Transfer of Control

No transfer.

h. Change in Style

The Sierra Leone game starts off with a kind of explanation or question-and-answer technique, followed by a multiple choice test. The rest of the two games are in a relatively uniform game mode.

i. Versatility of Response Techniques

The program provides recognition of number and work responses with complex branching to accommodate different answers.

7. Adaptability

At the present time two other school systems are studying the BOCES economics games with the view of putting them on their computer systems. The translation of the programs to Autocoder has made it relatively easy for the games to be played on other IBM 1401 computers.

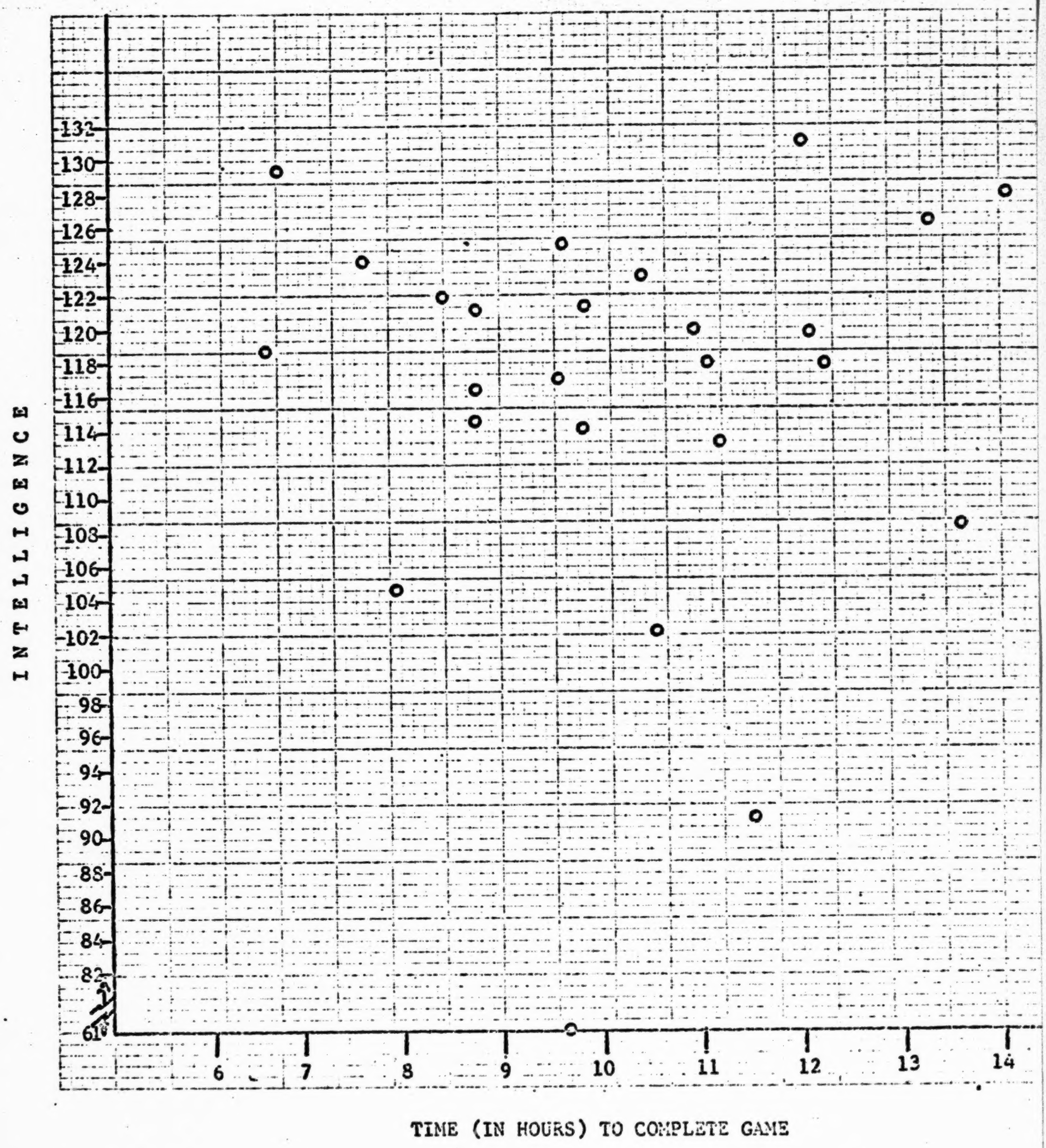

FIGURE 25. RELATIONSHIP BETWEEN INTELLIGENCE AND TIME NEEDED TO COMPLETE THE SUMERIAN GAME

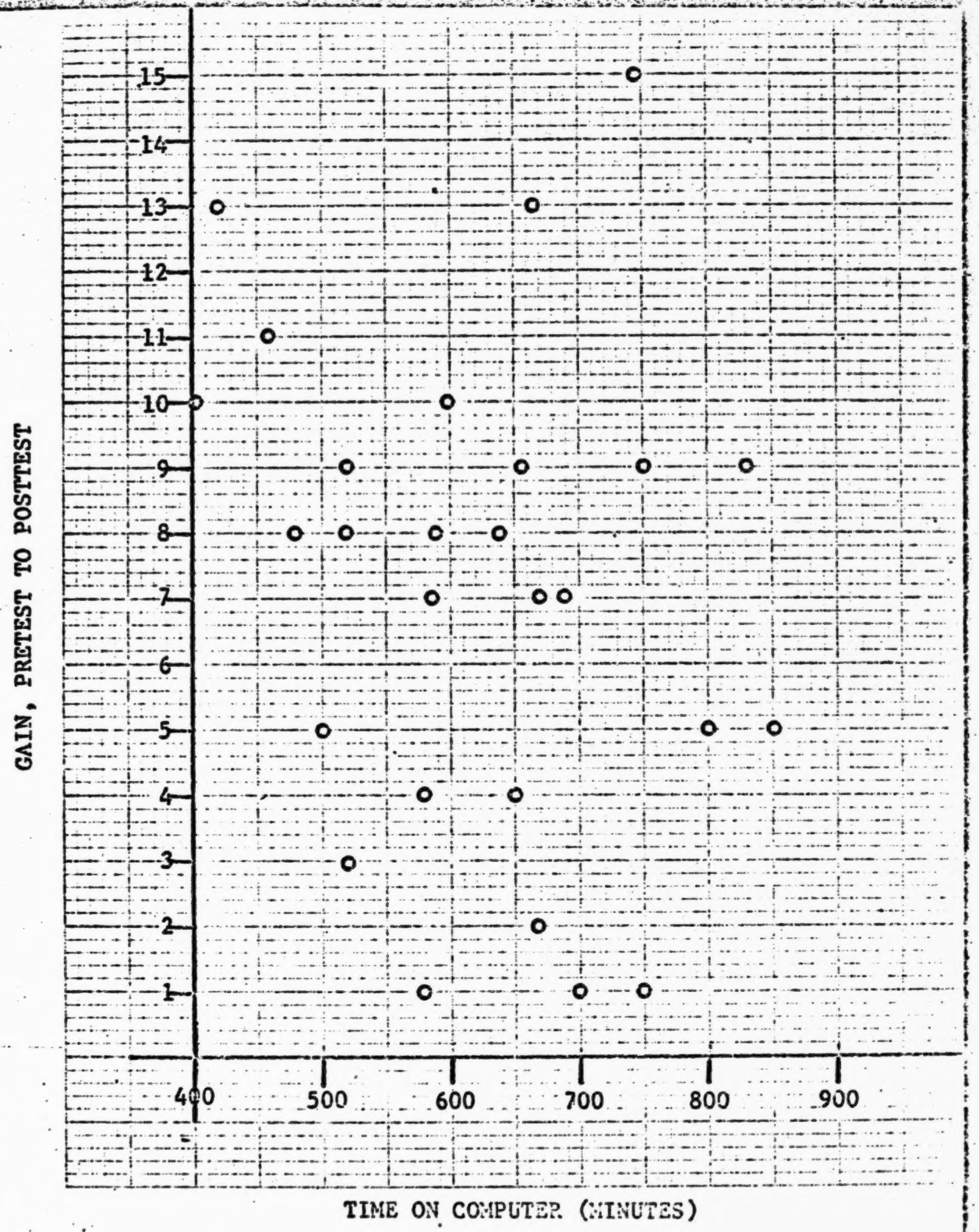

FIGURE 26 - RELATIONSHIP BETWEEN TIME ON COMPUTER AND GAIN ON TEST OF ECONOMIC UNDERSTANDING (SUMER)

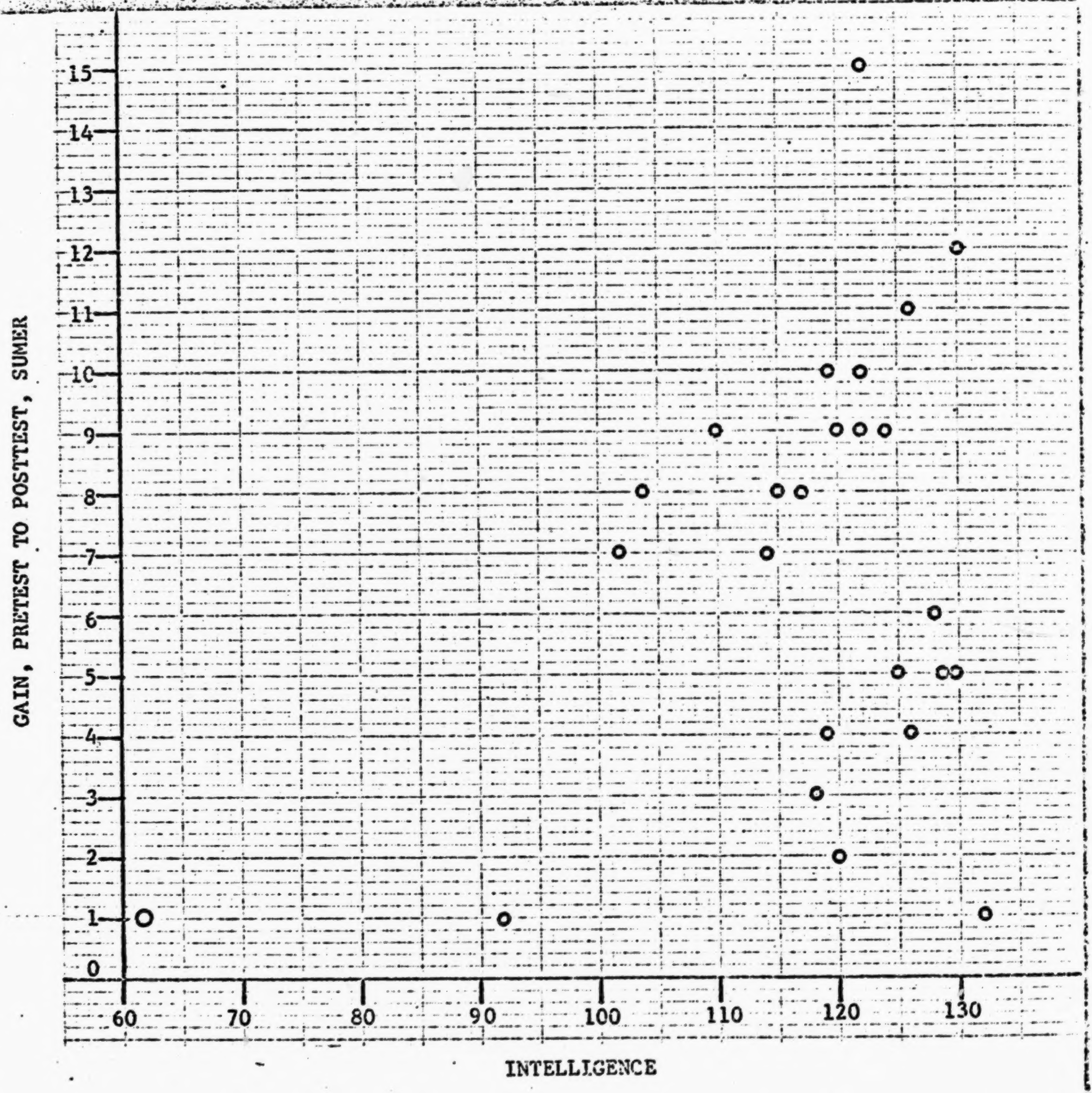

FIGURE. 27 - RELATIONSHIP BETWEEN INTELLIGENCE AND GAIN ON TEST OF ECONOMIC UNDERSTANDING (SUMER)

Conclusions

1. It is technically feasible for sixth-grade students to play economics games on a computer system. In the case of the Sumerian and Sierra Leone games the students experienced no real problems except in the case of two students with very low reading ability.

2. The computer-based economics games were at least as effective in teaching principles of economics as the classroom method with which the experimental technique was compared. On one game the experimentals gained significantly more from pretest to posttest than the controls. On the other game the controls gained slightly but not significantly more than the experimentals.

3. The control group showed more understanding of economic principles several months after the instruction than did the experimentals.

4. The game appears to have been superior in teaching interpretation of graphs and diagrams but not as effective in teaching facts.

5. The experimental group spent less time at the computer than the controls did in the classroom in the process of learning approximately the same materials.

6. The more intelligent students gained more while playing the game than the less intelligent students.

7. Students who read well gained more from the game than those who read less well.

8. The students who spent the least time at the computer made the greatest gains.

9. The students who did poorly on the pretest gained more from pretest to posttest.

10. There is only a very slight connection between intelligence and the time which pupils in the experimental class needed to complete the game.

11. Students who had otherwise been ranked low in terms of intelligence or speed of performance did well in the game situation.

12. The students enjoyed playing the economics games for the entire 15-hour period.

13. The computer games provided theoretical variability in six out of nine specified categories of individualization.

14. The Sumerian and Sierra Leone games may be played in other locations where a 1401 computer with operating terminals is located.

PART IV: IMPLICATIONS

Since BOCES is a demonstration center for CAI as well as a research center, many visitors come to see us and ask questions about the future use of computers in education. These questions generally fall into one part or another of the following groups:

A. Will computer-based instruction be widely used for education? Or more specifically,

   1. Will the costs become supportable?

   2. Can computers really make a unique contribution?

   3. Is CAI really much more effective in terms of

      a. teaching concepts and skills.

      b. saving instructional time.

      c. improving motivation.

   4. Can the problems of individualization be solved?

B. If computer-based instruction becomes widespread, what will the effects be on administration, organization, curriculum, methodology, staff, and students?

   Although no one knows for sure the answers to these questions, it is interesting to speculate about them in the light of experimentation and constant reflection on the problem.

In view of our present inability to answer these questions, extensive research should be conducted to provide us with better estimates of future usage.

CHAPTER 10: PREDICTIONS AND PRESCRIPTIONS FOR FUTURE COMPUTER-BASED INSTRUCTION

A. Will computers be widely used for education?

1. Costs. Our project has been expensive both in terms of the cost to produce game programs and in terms of the expense of computer rental. The cost can be partially justified by reference to the complexity of the game program, the quality of the visuals, and the experimental settings.

   Since we began our research in 1962, new systems have been devised which are more effective at lesser cost. Computer storage costs steadily decreased, CPU speed went up, new methods of programing cut the cost of preparing materials.

   Present costs estimates per student hour on the most economical systems now operative run from one to three dollars. It is expected that these costs will diminish.

   If instructional terminals are eventually linked to large time-shared computers which are used for business and clerical applications as well, the costs could well be even further reduced.

   Inseparable from the question of actual cost is the political matter of sources of support. If the federal government should decide to subsidize technologies such as CAI, school districts may be able to afford computer systems on a large scale.

2. Uniqueness. Ever since the computer began to be used for instructional purposes some ten years ago,it has seemed likely that the great speed and logical power of electronic data processing equipment could be used to provide learning situations which would be uniquely effective. Towards this end, teaching logics have been invented in a variety of modes - linear, branching, inquiry, tutorial, game form - each drawing upon the computer in different ways intended to exploit its power.

   Until more thorough exploration of teaching modes has disclosed the range of possible applications in education, it will be difficult to describe in any complete way what the special advantages of computer control are. Meanwhile on some fronts there is doubt that the computer can play anything other than a trivial instrumental role in the design and production of more effective learnin situations. The question is raised: "What can the computer do better than conventional texts, programed books, manual teaching machines, or board games?"

   Simulations of socioeconomic environments are ordinarily dependent upon the use of computers in order to attain a sufficient degree of realism so that the simulations "fit" the structure of real environment. If computers are not used in this endeavor, this commonly leads to simplification of the environmental model.

In some cases this may not be detrimental; it may even be desirable. Sometimes, however, the resulting model may deviate so far from reality that it is of questionable utility.

One of the main values of computers in the simulation of environments lies in their power to control models in the "simulated environment mode" of instruction allowing the following kinds of operations to be carried out in order to permit the artificially created situations to conform as closely as possible with reality.

a. Accurate calculations may be quickly made from simple or complex formulae.

b. In response to decisions of a player or "external" circumstances built into the model, it is possible to instantly modify the constants used in existing formulae or select entirely different formulae to utilize in computations.

c. "Random" numbers may be generated and used to modify the calculation of the outcome of a particular decision.

d. Complicating circumstances may be methodically introduced in a logically consistent manner not foreign to the way in which this would happen in the real environment.

e. Situations or elements may be introduced on a "random" basis, i.e., when the probability of situation A occurring at time t_i (in a "simulated future time" environment) is less than 1.

f. To provide clarification, variety, or realism to the simulated environment, computer-control is possible over peripheral audio-visual equipment: slide projectors, tape recorders, etc.

Each of these six advantages of computer-control over other models for the simulation of realistic environments for educational purposes is discussed in Appendix E. It remains to be seen whether these unique capabilities can be utilized in ways important enough to justify the cost of a computer system.

3. Effectiveness.

Teaching power.--

a. How well do students learn at the terminals? Our findings are that students learn economics at least as well by playing economics games on the computer as they do in regular classroom instruction. Considering that our games are primitive in respect to ideal games which may be produced in the future, some encouragement may be found in our experience. We have identified a number of improvements which would be made in the games to increase their teaching effectiveness.

Time.--

b. Related to the matter of effectiveness are questions about the possible saving of instructional time. Our experience indicates that a well designed program can cut instructional time at least in half. It may well be that more effective programs will be even more economical of time.

Motivation.--

c. Also relative are queries about the effect of computer-based instructions on student motivation. Present indications are that games and computer programs are fascinating to students. Perhaps some of the boredom and drudgery can be taken out of instruction.

4. Can the computer really individualize education? According to our findings the computer can theoretically provide nine forms of individualization:

   a. Change of content

   b. Extension of scope

   c. Change of pace

   d. Alteration of sequence

   e. Variation of difficulty

   f. Switching of presentation modes

   g. Transfer of control

   h. Change in style

   i. Versatility in modifying response techniques.

   Such an achievement cannot be fully realized without the solution of related problems of diagnosis, prescription and evaluation. All of these phases of individualized education constitute a logistic complex which will not be easy to organize in workable form. If a solution can be found for this configuration, the shortcomings of mass instruction may be remedied.

Unresolved questions.--

Predictions about future use of computers in education must be based on other considerations besides cost-effectiveness. Most of these factors are beyond our power to make any reliable judgment. The question form will be used.

1. Will CAI get a bad name because the first programs are produced in haste, are of poor quality, and do not really justify the use of a computer?

2. Will federal and state governments provide subsidies for the rental of computer systems?

3. Will public reaction be favorable or unfavorable?

4. Will the teaching profession be responsive to computers or resist them?

B. Effects on school operation?

Although some data processing philosophers speculate that schools may be abolished if and when education becomes automated, we will take the more cautious view that school practices may be considerably modified. Speculations can be made about the consequences of wide-spread adoption of computer-based education on administration, organization, curriculum, method, staff, and students.

1. Administration. Generally speaking, administrators are concerned and have to deal with nearly every aspect of school operation and and so all implications of CAI discussed above and below will have significance for them.

   There are some particular functions of an educational system to which administrators have to pay particular attention. Some intimations of the effect on administrators have been perceived in our small project. Administrators will have to become expert at

   a. Decisions about acceptance or rejection of technical systems, including promotion of change.

   b. Obtaining funds, preparing budgets for renting computers

   c. Scheduling of students.

   d. Hiring flexible, qualified people; setting salaries.

   e. Managing the logistics of individualized instruction.

   f. Running in-service training programs on programing and use of CAI systems.

   g. Explaining CAI to parents.

   h. Interpreting computers to Boards of Education.

The implication for administration is that future school officers will need special training in order to deal with these new problems.

2. Organization. In a school system equipped with an extensive data processing system there would be changes in how the varied administrative and learning activities were fitted together.

   a. Scheduling. If the instructional system were organized on an individualized basis, scheduling problems would be greatly multiplied, but the difficulties arising from uniform course length, conflicting schedules, uniform class hours, and the like could be avoided. The scheduling itself could be aided by data processing.

   b. Examination systems. In most countries of the Western World, a massive examination system organizes, or at least preserves the existing structure of the instructional offerings. If the learning programs were written so that the error rate was low, and periodic but painless checks indicated that students were learning as they went along, a good deal of the misery of grading and testing could be avoided and automatic records of progress could be maintained. Flexibility would become an organizational principle.

   c. Articulation. Nowadays school districts are organized into three inequal lumps - elementary, junior high or middle school, and high school. Transition from one section to another is notoriously poor. In a system made flexible through the use of individualzed instruction and scheduling, the crude breaks between levels could be eliminated.

   d. Miscellaneous rigidities. Some of the minor irritants which result from our present rigid scheduling conditions might be eliminated. For example, if a student were absent from school, he would not necessarily miss what the teacher was saying while he was gone but could pick up his program where he left off before he was sick. The same principle would apply to absences caused by group activities not in the automated program, such as athletics, music, dramatics, and the like.

3. Curriculum. The most important implication of computer-based instruction for curriculum is that it provides an opportunity for a breakthrough in the traditional content and organization of curriculum.

   For years geometry has been taught in the tenth grade substantially as Euclid organized it 2500 years ago. Statistics, however, a relatively new but important subject has not found its way into many school curricula. Now, by a simple request to the computer, statistics can be summoned at any time, and geometry can be divided into units, shortened, modified, or ignored.

   a. As soon as a variety of programs is produced, it will be possible to offer a range of electives limited only by program availability and not by the training of the staff. Thus a single school could offer training in a hundred different foreign languages instead of three or four.

b. In the American curricular pattern most subjects are taught an hour a day for about 180 days a year. When the year is up, many subjects are dropped, while certain traditional ones like history and English go on into another rigid 180 day sequence.

c. In a computer-based system set up to provide individualized instruction, units of any length can be written and adapted to the needs of each student.

The factors which produce our present, rigid, non-adaptive curriculum include traditional views on the part of teachers and parents limitations, teacher-training, problems of mass education, pressures from colleges and state education departments, and the textbook system in a kind of self-perpetuating environment. To the extent that automation frees the pupil from these rigid factors, it can modify the curriculum in the direction of flexibility, versatility, and adaptability.

4. Method. The consequences of computer usage for instructional method will be extensive, as suggested elsewhere in this report.

   a. Diagnosis. Until now it has been too much work to diagnose learning needs and capabilities of individual students. With the use of diagnostic instruments and processed records easily retrieved, personal attention could be paid to the differences among students.

   b. Prescription. With diagnostic information available, precise prescriptions for the selection of learning experiences appropriate to individual students would be made.

   c. Instructional mode. One day we will be able to determine what kind of instructional style works best for different people and adapt our methods to each.

   d. Use of materials. Eventually great quantities of recorded information, pictures, sounds, learning routines and opportunities, perhaps smells and tactile stimulations will be stored in computer memories.

   e. Evaluation. In learning programs of the future, measurement will be built in, progressive, comprehensive, and free enough from error so that bulk, end-of-term examinations will rarely be needed.

5. Role of the teacher. One fear that has been expressed is that the machines will replace the teachers.

The guess of those people who worked on the BOCES simulation project is that teachers will not be replaced but rather that their roles will change. Our experience has been that a great deal of effort has gone into the production of learning materials and programs, that the technicians were very important, and that we could have used more personnel in planning the diagnostic and evaluative phases of the instruction. In any educational system where there is extensive use of automated equipment, many educators will be needed for staff positions in production, management, diagnosis, and evaluation. Whenever automation is otherwise total there will be an opportunity for skilled teachers to work with individual pupils and with small discussion groups instead of conventional size.

A reasonable prediction is that through the combined activity of staff and technological aids an improved kind of education can emerge, if the staff assume somewhat changed roles.

Sample Staff Roles in a Computer-based Instruction System.

a. A Terminal Supervisor. We reproduce here the job description which we made for this purpose.

DUTIES OF TERMINAL SUPERVISOR

Technical Duties

At the beginning of the morning prepares equipment for first students.

Checks printout from the previous day for left-over difficulties.

Dials into the computer at IBM to sign on three terminals.

When students arrive, selects their individual programs and starts them off.

Periodically checks with students to make certain they are not having difficulties.

Reads over the printout to see that program is operating properly.

Periodically saves program to prevent loss in case of system failure.

Terminates games at completion.

Saves files.

Shuts down all terminals.

Teaching Duties

Observes students to make sure they do not give each other answers.

Prevents students from running around the room bothering other students.

Helps when student is confused by program.

Analyzes difficulties of various sorts and helps students.

Keeps schedule of student times on terminal.

Arranges for bus transportation in case of changes in schedule.

Keeps a record of student's time on terminal.

Mails homework assignment to the teacher-researcher.

Makes note of special problems that students have.

Administers posttests to students.

Calls IBM in case of technical difficulty.

Makes certain that other electrical appliances such as typewriters and coffee pots are not plugged into the computer circuit.

Interviews each student at the completion of a game.

Writes general observations about each student.

Summarizes observations in report to project director.

Makes record of individual standardized test data on each student.

b. Teacher-Researcher.

The duties of the teacher-researcher have been to create original instructional routines subsequently programed by a specialist in computer programing. The teacher-researchers in our project have been classroom teachers who spent part-time working on the production and adaptation of the computer materials. In our view they should be competent in the best conventional classroom methodology, imaginative, able to write effectively, and familiar with the capabilities of computer systems.

c. The Computer Programer.

When the teachers have finished producing the instructional materials, they have been converted into computer languages by professional programers from IBM or by persons who have learned to write computer programs.

Implications.--

Although no one can look accurately into the future, it is possible to speculate about some of the changes in staff roles which may occur as a consequence of the introduction of the electronic technologies. Basically we don't expect that there will be any reduction in the total numbers of persons employed by the educational establishment, but it is undoubtedly true that the roles of teachers and other educational personnel will be changed. Perhaps some of the directions will be these:

a. There will be a need for persons able to create instructional programs.

b. There will be a need for technicians.

c. There will be a need for teachers to master the skills of diagnosis in order to make proper use of the opportunities for individualization presented by the machines.

d. There will be opportunity for teachers to spend more of their personal time with students because some routine instructional activities can be performed by the media systems.

d. The role of administration should change in the direction of managing student progress in a much more complicated educational environment.

6. Students - Dehumanized? One common question about computerized education is whether it will dehumanize education, a thought usually expressed as a fear. This fear is expressed frequently enough to warrent some analysis of the complaint.

The common-sense notion of "humane treatment," or whatever the antithesis of "dehumanization" is, seems to be something like this: the human teacher when present in the flesh pays attention to individual needs of her pupils by diagnosing their educational needs, providing them with personal treatments; she supplies emotional reinforcement to learning by praising, blaming, or sympathizing with her pupils; and the teacher inspires and motivates by showing enthusiasm and providing examples of model conduct.

It is helpful to divide these human behaviors into two classes: affective and procedural.

a. Affective "humanism." The praising, blaming, encouraging, sympathizing, forgiving, unforgiving actions of teachers have an emotional, unique characteristic which computer programers will be hard put to reproduce. To provide such personal attention for all pupils now in school, however, there are not enough sympathetic mentors to go around.

b. Procedural "humaneness". The other phase of "humane" treatment consists of a series of actions on the part of the teacher whereby she provides differentiated opportunities for her pupils to learn. This "individualization" which we have previously analyzed in detail is certainly part of the common-sense notion of humanization.

Computer systems will probably make it possible for the procedural kinds of "humanization" to be done better. They will probably never be a perfect substitute for the affective humanization which we value highly and find on occasion.

There is one special case of "dehumanization" in which automated systems may excel, and that is in teaching children with certain kinds of emotional disturbance. For those pupils who work best in isolation, the electronic carrel may be a superior kind of environment. Dehumanization may humanize for some purposes.

CHAPTER 11: FUTURE RESEARCH

The experience with Project 2841 indicates that fruitful research might take these directions in the future.

1. Experimentation with computer-based games should be pursued.

   As the result of listening to consultants and reflecting on our own we have decided that a number of improvements should be made in the games. Some of the changes contemplated are to make use of the random access tape recorder in order to provide aural instruction, to exploit the increased capabilities of advanced systems, to make the slides contribute more to the understanding of economic principles, to recognize other objectives besides economic ones, to increase the realism of the simulated situations, to create a greater variety of instructional routines, to provide opportunities for conscious transfer of understandings from one situation to another, to experiment with a technique which might be called pseudo-documentation, to build in better diagnosis of student understandings, and to improve the measurement of understanding by the exploitation of a depth interview procedure.

2. New topics should be explored to see what other kinds of simulation are possible.

3. New configurations of the simulated learning environment style should be developed.

4. Different technological instruments should be utilized, such as the random access sound drum and the light pencil.

5. New styles of teaching logics should be invented and tried out, in addition to linear, branching, and simulated environment styles.

6. Further exploration should be made of the use of auditory and visual cues to prompt constructed answers.

7. Further study should be made of the possibilities of using computer logic and storage capabilities to analyze and compare student responses.

8. Experiments of some length should be completed in order to test the long-term effects of automated instruction.

9. The computer industry should be encouraged to search for an improved technology which would include devices capable of voice recognition, language interpretation, olfactory simulation, tactile simulation, storage of moving picture sequences, and others.

10. Improvement should be sought in the methods of communication among persons engaged in simulation and computer-assisted instruction.

11. More study should be made of the diagnostic and evaluative aspects of automated instruction.

12. Systematic programs should be devised in which many different computer applications are combined.

CHAPTER 12: SUMMARY

Theoretical Basis for the Experiment.--Philosophers of education agree that effort is needed to bring about individualized instruction, since the present educational system is constrained by factors which have produced instead relatively rigid, sterile, and insensitive procedures. Simulation is one method of organizing learning environments to provide for individualization in a broad sense. New technologies have been invented and, to a limited degree, explored for educational uses.

The purpose of the experiment here reported was to produce and evaluate computer-based economics games as a method of individualizing instruction for sixth-grade pupils.

Description of the Games.--During the course of the project three games were developed: The Sumerian Game, The Sierra Leone Game, and The Free Enterprise Game.

Of these, the first two were used in a formal experiment and were programed for a special IBM 7090 time-shared computer. The third game was completed after the experiment and was programed in Autocoder for a 1401 computer.

In the Sumerian Game the student takes the role of a priest-king in a Sumerian town about 3500 B.C. Through an introductory slide and tape presentation the pupil is given an orientation to the scene. Then, seated at the typewriter terminal of a computer system, he is presented with a series of economic problems, such as how much grain he should plant, store, or distribute to the population, how much manpower to assign to development of new crafts, whether to accept certain technological innovations, and how to cope with disasters which are introduced randomly throughout the game. Information is presented by means of printout, and the setting is illustrated with slides.

In the Sierra Leone game the pupil plays the part of an A.I.D. officer in modern Sierra Leone. After taking a simulated tour of the country, he is assigned to each of the three provinces of Sierra Leone, one after another, and gives advice to the local administrators about their economic problems, such as land reclamation, price control, and even gross national product allocations. If he is successful in advising the country on these problems, he is promoted within A.I.D.

The third game, Free Enterprise, puts the student in charge of a toy store and later a toy factory to give him simulated experience with economic problems which occur in these occupations.

The equipment used for the games originally was a time-shared IBM 7090 connected by telephone line to three 1050 terminals at our Center. Each terminal was equipped with an experimental slide or film strip projector. At the present time the third game and parts of the first two have been reprogramed in Autocoder and are running at our Center from a 1401 computer at Johns Hopkins University. The instructional versions of the games were written by teachers and then the games were programed in FORTRAN Assembly Program by IBM. The computer programs for these games are quite complex and differ in essential ways from linear or simple branching programs.

Experimental Procedures.--In order to assess the results of the games, an experiment was set up along these lines. From October 1963 to March 1966, twenty-six sixth-grade students from the Mohansic School in Yorktown Heights, New York, played two games, The Sumerian Game and The Sierra Leone Game, on three terminals at the Center for Educational Services and Research of BOCES. Meanwhile a control class of equal ability studied about the economics of life in Sumer and Sierra Leone under the direction of a talented teacher using ingenious but "conventional" methods.

The effectiveness of the whole experiment was measured by several different techniques. One was to observe the students carefully and interview them after they finished playing the games. Another was to compare their pre- and posttest scores on specially prepared tests of economic understandings, and a third was a depth interview technique designed to probe for understanding of economic concepts on the part of selected pupils.

Before and after the experimental use of the terminals all students in both control and experimental classes were pretested with the "Test of Economic Principles Based on Ancient Sumer" and the "Test of Economic Principles Based on Sierra Leone" prepared for the project.

Conclusions.--

1. It is technically feasible for sixth-grade students to play economics games on a computer system. In the case of the Sumerian and Sierra Leone games the students experienced no real problems except for two students with very low reading ability.

2. The computer-based economics games were at least as effective in teaching principles of economics as the classroom method with which the experimental technique was compared. On one game the experimentals gained significantly more from pretest to posttest than the controls. On the other game the controls gained slightly but not significantly more than the experimentals.

3. The control group showed more understanding of economic principles several months after the instruction than did the experimentals.

4. The game appears to have been superior in teach interpretation of graphs and diagrams but not as effective in teaching facts.

5. The experimental group spent less time at the computer than the controls did in the classroom in the process of learning approximately the same materials.

6. The more intelligent students gained more while playing the game than the less intelligent students.

7. Students who read well gained more from the game than those who read less well.

8. The students who spent the least time at the computer made the greatest gains.

9. The students who did poorly on the pretest gained more from pretest to posttest.

10. There is only a very slight connection between intelligence and the time which pupils in the experimental class needed to complete the game.

11. Students who had otherwise been ranked low in terms of intelligence or speed of performance did well in the game situation.

12. The students enjoyed playing the economics games for the entire 15-hour period.

13. The computer games provided theoretical variability in six out of nine specified categories of individualization.

14. The Sumerian and Sierra Leone games may be played in other locations where a 1401 computer with operating terminals is located.

Implications.--Since BOCES is a demonstration center for CAI as well as a research center, many visitors come to see us and ask questions about the future use of computers in education. These questions generally fall into one part or another of the following groups:

A. Will computer-based instruction be widely used for education? Or more specifically,

   1. Will the costs become supportable?

   2. Can computers really make a unique contribution?

   3. Is CAI really much more effective in terms of

      a. teaching concepts and skills.

      b. saving instructional time.

      c. improving motivation?

   4. Can the problems of individualization be solved?

B. If computer-based instruction becomes widespread, what will the effects be on administration, organization, curriculum, methodology, staff, and students?

Although no one knows for sure the answers to these questions, it is interesting to speculate about them in the light of experimentation and constant reflection on the problem.

In view of our present inability to answer these questions, extensive research should be conducted to provide us with better estimates of future usage.

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PART VI: APPENDIXES

APPENDIX A: TESTS OF ECONOMIC UNDERSTANDING

SCHOOL____________________ NAME____________________

TEACHER____________________ DATE____________________

TEST ON ECONOMICS PRINCIPLES
BASED ON ANCIENT SUMER

PART A: Multiple Choice

For each of the following questions or incomplete statements, choose the one best answer and place the corresponding letter in the parentheses at the right.

1. If the supply of a product increases at the same time the demand for it decreases, its market value will a) fall; b) rise; c) be undetermined; d) remain exactly the same. ( )

2. If the demand for a product increases, the increase in value which follows usually causes a) more of the product to be produced; b) less of the product to be produced; c) no change in production; d) the making of the product to be stopped. ( )

3. Specialization and trade between countries usually leads to a) the interdependence of both countries; b) the production of fewer goods; c) the economic instability of both countries; d) the fame of both countries. ( )

4. If the demand for a product declines a) the hiring of more workers follows. b) the rate of production slows down temporarily. c) the value of the product increases. d) the product is worthless. ( )

5. Compared with the economy of the United States today, the economy of Sumer at about 3000 B.C. a) was much more productive; b) had more government ownership and control; c) better satisfied the wants of the people; d) had more private businesses. ( )

6. When a country overproduces a) trade for luxuries is made possible. b) the waging of offensive wars is encouraged. c) the worth of the craftsmen is increased. d) none of these. ( )

7. When a large company that manufactures television sets finds its profit has become very high due to a great demand for its sets, it will probably a) fire many workers so as to reduce the cost of making television sets. b) distribute all of the profits to the workers as a bonus. c) spend money on research so as to build better sets or different products. d) sell some of the machines in the factory in order to reduce the cost of staying in business. ( )

8. When technological inventions are encouraged a) production is increased. b) the study of science is no longer required. c) the standard of living is lowered. d) none of these. ( )

9. When the working population of a City-State decreases a) production increases. b) the value of commodities goes down. c) it is necessary to provide more factories. d) none of these. ( )

10. By establishing schools a country a) can plan its profit and loss budget more effectively. b) does not alter its tax program. c) must go outside its borders for all of its teachers. d) none of these. ( )

PART B: True-False

Read the following statements. Put a T after the sentence if you think the statement is True and an F if you think the statement is False.

11. In order to increase your wealth, extra income should be put to work to make more capital. ( )

12. Resources like fertile soil, water, grain and wool should be used to satisfy only the very basic needs of a people. ( )

13. The economic activities of a primitive people are marked by a constant circulation of wealth from the people and back to the people. ( )

14. When an invention increases the output of a product beyond the internal needs of a country, it is unwise to adopt the invention. ( )

15. One reason why trading for desired products is better than taking them by force is that trade also permits an exchange of ideas between countries. ( )

16. The use of a middleman in trade is never an advantage because a merchant should always go directly to the source of the goods he needs. ( )

17. Specialization in crafts increases the efficiency of the workers as well as the wants of people. ( )

18. The happiness and behavior of workers can be improved by satisfying their wants beyond basic necessities. ( )

PART C: Matching

19 - 23. Problem:

How to keep a surplus of grain for emergencies and for trade.

Consider this story:

In your temple granary in Erech you have stored many bushels of grain for the coming year. Your census taker has just informed you that your population has increased considerably since last year. Many people have migrated here from the desert lands to the west, where lack of food often drives many hungry people to your gates. Many new babies also have been born to your people. Your scribes have indicated that the supply of grain will feed this increase in population but will leave no surplus to meet any disaster or to trade for products that you do not have.

Five possible solutions are listed below in the first column. In the second column are possible new problems which might arise from using each solution. Match the new problem with the solution it goes with by putting A, B, C, D, or E in front of it.

Solution

A. Throw out all immigrants.

B. Put everyone on leaner food rations.

C. Employ fewer craftsmen.

D. Cut down on trade.

E. Put more land under cultivation.

New Problem

( ) Illness and dissatisfaction due to improper feeding

( ) Fewer markets for surplus goods

( ) Expense of irrigation works and tools

( ) Slow down in production

( ) Stirring up anger in people and possibly leading to war

( ) More trouble with rats

PART D: Completion

All production (whether people are raising crops or making things) must have these four factors: natural resources, labor, capital and management. Imagine that you are living in one of the coal mining areas of the United States. In your society give an example of these four factors.

24. Natural resources:

25. Labor:

26. Capital:

27. Management:

Complete the following statements, choosing words from the list.

Record

Last

Lives

Resources

Leisure

Increase

Technological inventions

Improved transportation

Decrease

Popular demand

28. Since there is a limit to the time certain goods can be stored, a complete ________________ should be made of goods on hand.

29. It is important to save, since disasters may result in the loss of __________ ______________________________.

30. One important result for the individual when the standard of living is raised is more ____________________ .

31. As population increases, the output of materials must ____________________.

32. ______________________________, ______________________________, and ______________________________ can greatly increase the quantity of goods produced.

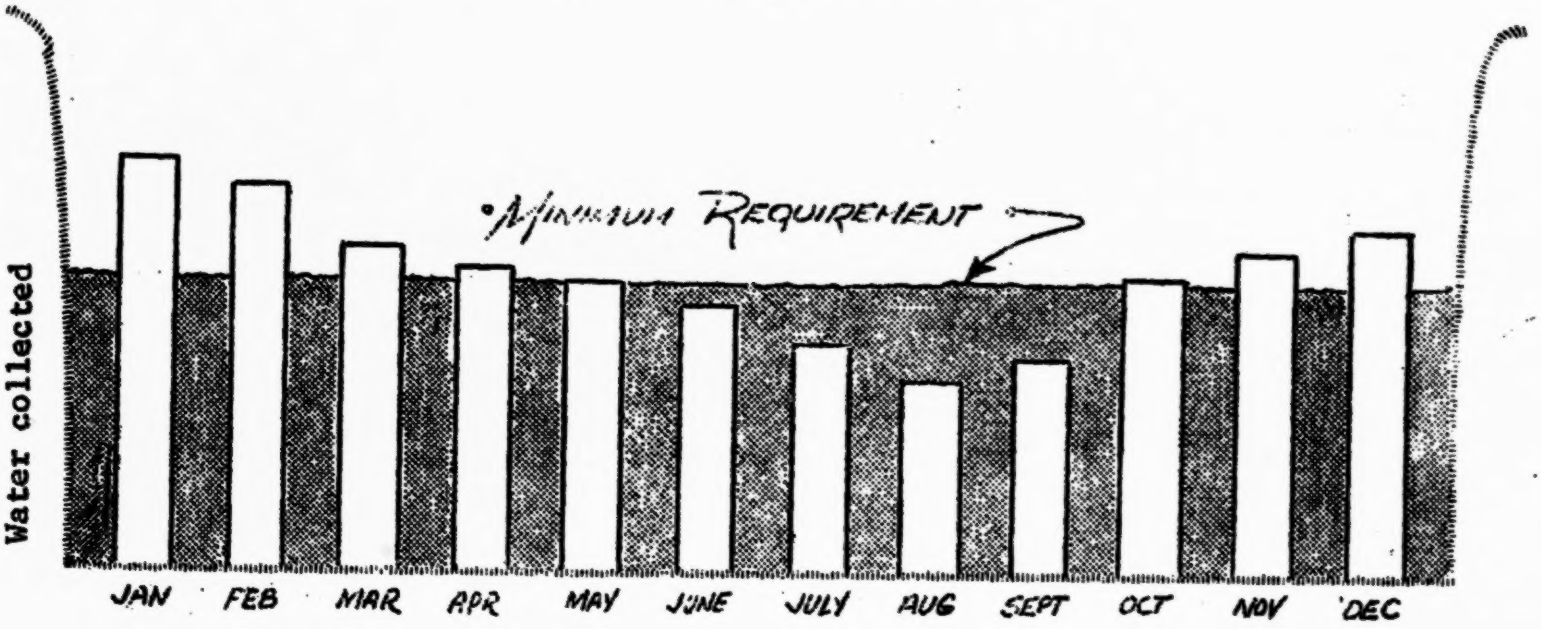
Metal Workers	+	Welders	=	Metal Sinks Produced
4	+	1	=	3
4	+	2	=	6
4	+	3	=	9
4	+	4	=	12
4	+	5	=	13
4	+	6	=	14
4	+	7	=	14

The above table shows the number of metal sinks produced when more and more welders are added to the same number of metal workers in a factory.

33. Explain why the production figures are as they are when 5, 6 and 7 welders are added.

34. What would happen to production if you added more than 7 welders?

35. In your own words, what rule have you been using to answer the questions?



The graph shows the following:

1. A solid line to indicate the amount of water needed each month.
2. Bars to show the amount of water that can actually be collected each month.

Questions

33. What could you do during December, January, February, and March to take care the shortage that exists in collection during the months of June, July, August, and September?

34. In view of your answer to 33, what does this mean in terms of the way a government should handle important materials?

SCHOOL ______________________ NAME ______________________

TEACHER ______________________ DATE ______________________

TEST ON ECONOMIC PRINCIPLES
BASED ON SIERRA LEONE

This test tries to see how much you know about the economy of Sierra Leone. Some of these questions are quite difficult, but you should study the questions carefully and do as well as you can.

PART A: Multiple Choice

Select the letter which provides the best answer and write the letter in the blank space at the right.

1. A favorable balance of trade is achieved when a) a country's exports are greater than its imports; b) a country's exports are less than its imports; c) a country is able to trade with all nations; d) a country trades with very few countries. ( )

2. Which of the following is most important for achieving a favorable balance of trade in Sierra Leone? a) increase in scientific farming; b) increase in money supply; c) increase in population; d) increase in automobile production. ( )

3. A higher standard of living can best be achieved by a proper balance of a) land, water power and equipment; b) land, labor and equipment; c) labor, water power and mining; d) equipment, water power and mining. ( )

4. In striving for a prosperous economy a young, growing nation should a) emphasize manufacturing; b) emphasize mining; c) emphasize agriculture; d) divide the emphasis equally among all three. ( )

5. A valuable source of food for Sierra Leoneans is a) rice; b) tomatoes; c) pepper; d) salmon. ( )

6. A main mineral product of the Eastern Province in Sierra Leone is a) bauxite; b) diamonds; c) silver; d) gold. ( )

7. A good method of measuring how fast a country grows economically is to pay attention to the a) population rate; b) export-import totals; c) Gross National Product; d) tax rate. ( )

8. Of the following, which is the feeling of the Sierra Leone Government? a) Foreign help and money are now welcome. b) The United Nations will help Sierra Leone so that other help is not needed. c) All the African countries will help each other economically. d) Foreign help and money are welcome. ( )

9. Which one of these is true of the cooperatives in Sierra Leone? a) They are usually able to operate more efficiently than individuals. b) They are not able to get enough money to grow. c) They are disliked by the people and the government. d) They produce poor products. ( )

10. For the improvement of Sierra Leone's economy, education is most important in a) training skilled people; b) offering adults an opportunity to study; c) teaching children the history of Sierra Leone; d) teaching English. ( )

11. An important result of a strike of workers raising a crop which is imported as well as exported is a) loss of workers times; b) loss of government taxes; c) ill feeling between workers and government; d) an unfavorable balance of trade. ( )

* * * * * * * * * * * *

Imagine that you are the Minister of Finance in Western Slobbovia, which is a young, growing country. You will be collecting money for the government and spending it to help the country grow. This country has a plentiful supply of nickel; it raises a good deal of spinach, and it is just starting to manufacture yo-yo's. On the basis of your experience with the Sierra Leone economy, answer the following questions. Select the letter which provides the best answer and write the letter in the blank spaces.

12. Assuming a three phase plan of economic development, during the middle period which of the following would provide you with the greatest amount of money? a) spinach; b) nickel; c) yo-yo's; d) tourists. ( )

13. Manufacture of yo-yo's will be most important to Western Slobbovia during which of the following periods a) middle; b) beginning; c) last; d) all of these? ( )

14. The Gross National Product will rise rapidly during the beginning of the first period due mainly to a) spinach; b) nickel; c) tourists; d) yo-yo's. ( )

15. There is danger in depending too much on spinach to raise the Gross National Product because a) the world's population may no longer buy spinach; b) there may not be enough transportation; c) your country and neighboring countries may have a large harvest; d) (All of these are correct.) ( )

* * * * * * * * * * * *

16. For an extended period of time which natural resource should not be depended upon too heavily for government income? a) water; b) lumber; c) tin; d) nickel. ( )

17. Between 1950 and 1965 many African countries achieved the goal of a) military strength; b) economic strength; c) independence; d) agricultural efficiency. ( )

18. Until 1961 Sierra Leone was controlled by a) France; b) Belgium; c) Portugal; d) Great Britain. ( )

19. Originally, Sierra Leone was founded as a settlement for a) tobacco planters; b) former slaves; c) diamond miners; d) fishermen. ( )

20. Sierra Leone is divided into how many provinces? a) 1; b) 2; c) 3; d) 4. ( )

Study the following chart carefully.

Farmer's Investment in Labor, Equipment and Land	Bushels of Corn Produced	Average Production in Bushels for Each Dollar of Investment
$500	600	1.2
1000	1400	1.4
1500	2700	1.8
2000	3200	1.6
2500	3500	1.4

The following questions are based on the above chart. Select the letter which provides the best answer and write the letter in the blank space.

_______21. In order to manage his farm most efficiently, the farmer should stop corn production at what figure? a) 600 bushels; b) 1400 bushels; c) 2700 bushels; d) 3200 bushels.

_______22. In order to efficiently manage his farm, the farmer should hold his investment to what amount of money? a) $500; b) $1000; c) $1500; d) $2000.

_______23. For each dollar invested, the farmer would want to receive the greatest number of bushels per dollar. He does this by producing how many bushels of corn? a) 600; b) 1400; c) 2700; d) 3200.

_______24. Each bushel of corn is most expensive to produce when the farmer produces how many bushels of corn? a) 600; b) 1400; c) 2700; d) 3200.

_______25. In order to raise more bushels for each dollar of investment, this farmer should: a) use new methods of farming; b) get a decrease in the selling price of the product; c) sell half his land; d) all of these.

PART B: Matching

Match the correct term in Column A with the correct explanation in Column B:

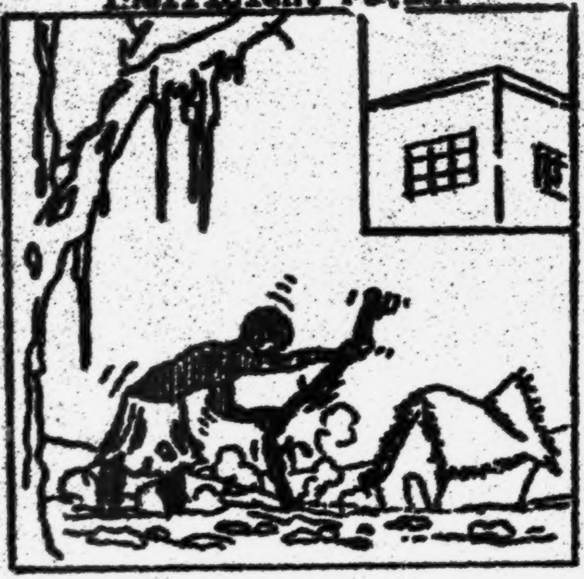
Column A

- ( ) AID
- ( ) Production Marketing Board
- ( ) Central Selling Office
- ( ) World Bank
- ( ) Cooperative Society

Column B

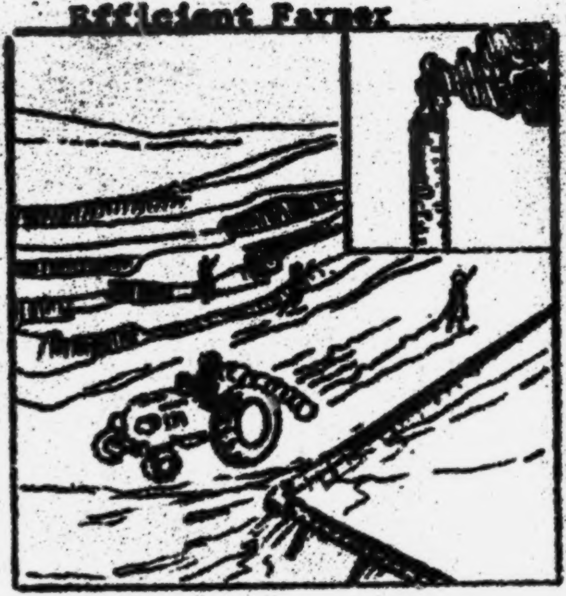
1. Sierra Leone government agency in charge of mines
2. International organization which helps young, growing nations
3. Sierra Leone government agency to watch the supply and price of goods.
4. U. S. agency in charge of law enforcement
5. A business organization owned and managed by the members who belong to it
6. U. S. agency in charge of helping needy countries.
7. Worldwide organization which buys and sells most of the world's diamonds

Inefficient Farmer



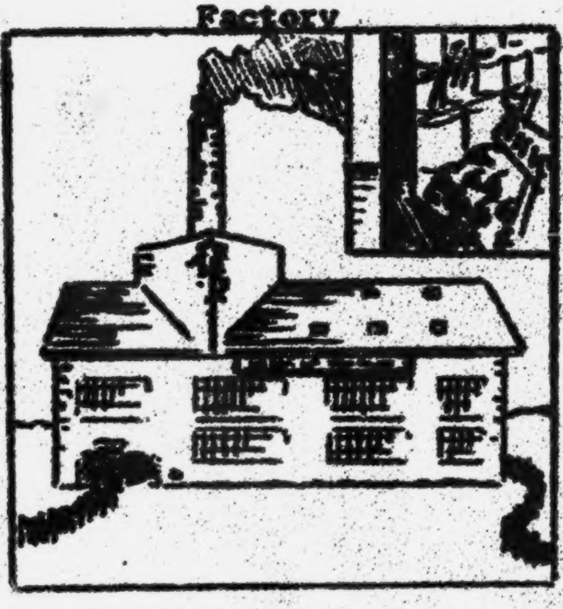
FRAME 1

Efficient Farmer



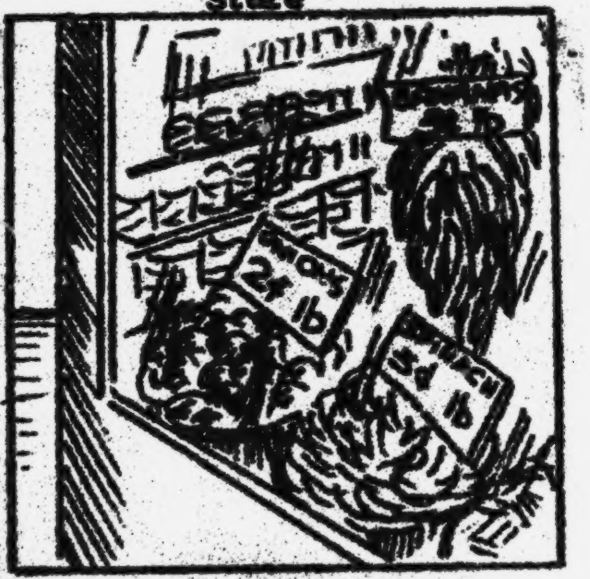
FRAME 2

Factory



FRAME 3

Store



FRAME 4

Select the best item in Column B to match the corresponding item in Column A. You may use the same answer more than once. Place the letter in the blank space. Remember that all four frames tell a story.

Column A

_______ 1. Frame #2 depends on Frame #1 in terms of:

_______ 2. Frame #3 depends on Frame #2 in terms of:

_______ 3. Frame #4 depends on Frame #2 in terms of:

_______ 4. In reference to export and import, frames #2 and #3, together, lead to:

_______ 5. Frame #2 contributes to all of the items in Column B except:

Column B

A. Low cost

B. Favorable balance of trade

C. Efficient Mining

D. Future labor supply

PART C: Completion

Complete the following with the correct word or words. Think carefully and then write the correct word or words in the blank space:

1. The city of Washington, D.C. is similar to what city in Sierra Leone?

   ____

2. If Sierra Leone exports 60,000,000 Leones and imports 65,000,000 Leones, how much should exports be increased to achieve a favorable balance of trade?

   ____

3. A farmer in Texas is having a problem with heavy rains which wash away soil and young plants. Can you suggest an agricultural method to stop this washout? ______________________________

4. Another farmer in India is having a problem with low crop production. He grows cotton, beets, and stringbeans on his farm planting the cotton, beets, and stringbeans on the same field year after year. Can you suggest the name of an agricultural method to increase his low crop production? ______________

   ____

5. The President of the United States is roughly equal to what government official in Sierra Leone? ______________________________

6. If you were the owner of a shoe factory and you had a three-year supply of shoes, what would you do to the price of shoes you had?______________

   ____

7. If you were the owner of a baseball factory and you had a two-week supply of baseballs in early April, what would you do to the price of baseballs you had?

   ____

8. If you were the father of a large family, would you be likely to buy shoes for your children when the factory owner had a: (1) three-year supply or when he had a (2) three-week supply? Remember, you want to save money:

   ____

9-10. The sale of diamonds in Sierra Leone is related to the game called Monopoly. In fact, the sale of diamonds in Sierra Leone is a monopoly. In order to have this diamond monopoly, you must control two economic factors. What are these two factors?

   ______________________________and______________________________

APPENDIX B: INTERVIEW UPON COMPLETION OF SIERRA LEONE AND SUMER

ECONOMIC COMPUTER GAMES

Student's Name

____

1. Did you enjoy the courses on the computer?

14 - yes
0 - no

a. if yes, why
~~b. if no, why~~

Frequency		Phrase Used
6	-	"It was fun" ("fun way to learn")
4	-	"More interesting"
5	-	"Different" ("Different than routine")
2	-	"I learned a lot"
2	-	"I liked typing"
2	-	"I like missing school
1	-	"It works with only one student at a time"

2. Is there anything about the courses that you specifically did not like? If so, what

4 - no
10 - yes(2 - machine errors - ("Print out"; "machine didn't under-)
((stand (spelling) mistakes like)
((teacher")
(5 - too long, boring-3 refer specifically to sumer
(2 - sumer too repetitious
(1 - "sumer forces right answer to discussion - ;couldn't do otherwise"

3(A) Do you enjoy school?(B) What are your favorite subjects?

(A)
9 - yes
3 - "yes and no"
2 - no

(B) Of the fourteen students,
7 listed Science as one of their favorites
3 - Math
3 - Spelling
3 - S. S.
2 - Eng.
2 - Gym
2 - Reading
1 - Riding
1 "Everything but homework

4. Would you like to have the computer for a teacher all day long? half a day? not at all?

4 - all day
9 - half day
1 - not at all

5. Were you excited (or scared) the first day that you were to run on the computer?

9 - excited
2 - scared
2 - both
1 - neither

6. What did you think you would be doing when you first were told that you would be coming to BOCES for computer courses?

5 - thought there would be a big machine
3 - thought they would work with typewriter
2 - see pictures, movies, hear things
2 - thought it would be different than it was
1 - work with games, answer questions
1 - didn't know

7. Can you type at all?

6 - yes
6 - a little ("just learning"; "slowly"; "not touchtyping")
2 - no

Could you type before you came to BOCES?

4 - yes
2 - a little
8 - no

Did you enjoy punching the keys and entering your answers on a typewriter?

14 - yes
0 - no

Did you have any trouble doing this?

12 - no
2 - "a little"

8. What did your parents think about the printout that you took home with you?

5 - "they liked it"
3 - "they thought it was "interesting"
2 - "good experience"
2 - "wanted to show it to others"

1 - "complicated"
1 - "didn't understand some of it"
1 - ("no basis for comparison (to realize progress"

(A)Did they every see your Sumer printout?(B)What did they think of that course?

(A)
2 - yes
4 - no
8 - no answer

(B)
1 - "liked sumer better"
1 - parents interested
12 - no response

9. Did you enjoy playing the role of somebody else? (that is, an officer of the United States Government in Sierra Leone; and Luduga the priest-king in Sumer)

12 - yes
2 - no (both would rather be themselves)

10. A What did you think of the homework assignment in the Sierra Leone course? B. Did you understand it without any explanation?

(A)
3 - liked having homework ("Necessary"; good to have an assignment")
4 - didn't like having homework ("not necessary") ("silly")

(B)
5 - yes
9 - no

11(A)Did you like the slides for the Sierra Leone game?
(B)Could you have enjoyed the game without them?

(A)	(B)
11 - yes	10 - yes ("could, but they were an interesting part of it")
1 - no	3 - no ("gave more of an idea of what it was about")
1 - some	1 - didn't know
1 - no answer	

12.(A)Did you like the slides for Sumer?
(B)(if the student used the RASP -- did you see any pictures on your projector?(C)Was it broken at all during your course?(D)If you saw pictures, did you like them?)

(A)	(B)	(C)	(D)
6-yes	8-yes	2-broken	5-saw some; liked what they saw
1-no	5-saw some	12-no ans.	3-yes, picture clear
5-some	1-no		2-no, could barely see picture
2-no answer			1-"I knew what would happen by picture that appeared"
			3-no answer

13(A)Do you think that you learned alot from the computer course?(B)Would you like to play another game?

(A)	(B)
12 - yes	13 - yes
2 - not a lot, but some	1 - "I'd be willing---"

14A)Did you mind having to interrupt your daily lessons in the classroom in order to come to BOCES for the computer courses?B)What classes did you usually miss?

(A)	(B)
3 - yes ("would rather come after school")	7 - (Riding, Math for SL, SS, (Science, Eng. for Sum.
10 - no	4 - Math, Reading
1 - no answer	1 - Eng., SS
	2 - no answer

15.A)Did you ever get tired or bored?(B)Would you have liked a longer time to work on the computer a shorter time?

(A)		(B)
11 - yes	(5 - Sumer	7 - longer time
	(2 - S. L.	0 - shorter time
	(1 - both	6 - "just right" now
	(3 - didn't specify	1 - no answer

16.. Which game did you like the best? Why?

8-liked Sumer best-5 of the 8 that liked Sumer best also indicated above that they were tired or bored by Sumer-("Sumer more interesting because it had taken place"; kingly thing to do";"master of game"; "dying population...knew better as game went on"; was more to do, had to think harder"; "liked special messages")

4-liked S.L. best^3 learned more about country in SL than Sumer, liked doing different things

2 - liked both

(orientation)

17. What did you think a computer was before your/trip to the IBM building?

5 - knew what computer was
8 - big machine - ("with blinking lights" (2); "with tape reels";
"with men working on it";fed cards-would ans. any question"
1 - big dark room with big movie screen

Were some of your questions answered during that trip?

11 - yes
2 - no
1 - didn't have any questions

Did you enjoy seeing the building, all the equipment, and the computer?

13 - yes
1 - was there before

18. If you played another computer game, what subject would you like it to be on? (science, math, English, reading, history, etc.)

5 - Science
2 - English
5 - History ("Italy long ago"; "Middle Ages")
2 - no preference

19. Would you have like playing the game, if you were in your own private sound-proof booth where no one could disturb you?

8 - yes ("less noise"; "no one would disturb")
5 - no ("couldn't talk with pthers")
("no, if I needed help")

20. Did you have any difficulty reading the printout on the typewriter?

1 - yes
6 - no
6 - sometimes - ("when print was light")
("had trouble understanding words")
("when machine went wild")
1 - no answer

Would you have liked the game to have gone slower or faster? (reading speed of printout)

2 - faster
2 - slower
9 - okay as it was
1 - "begin slower, toward end faster"

APPENDIX C: DEPTH INTERVIEWS

(Report by Gertrude Eckelt)

The Depth Interviews were conducted to measure concepts and understandings as induced by the alternate forms of teaching methods.

The interviews were conducted with both the control group as well as the experimental group, with students of equal intelligence in both groups.

Key questions were first asked which allowed for a spontaneous answer, which were followed by probing; namely, asking the same question in a different way or, for greater clarification, to lead the student into his own analysis of the question.

Probing in a depth interview is an important method to make the student aware of his potential grasp of a given subject and help him to express himself and thus help ~~him~~ to understand.

The questions were specially constructed to probe into a whole concept of economics with reference to specific instruction dealing with "Sierra Leone," a small country located on the West Coast of Africa.

There were five students from each group, with one person doing the interviewing with the aid of a tape recorder. The students were interviewed individually and put at ease by such questions as name, age, grade, number of sisters and brothers, what they did for recreation, the books they read.

There were two sets of structured questions for both the control and experimental group to measure their attitudes toward terminal computer instruction and their relationship towards regular classroom instruction.

The control group was asked the attitude to classroom instruction in relationship to terminal computer instruction, with which they were only vaguely familiar.

The students who were part of the experimental group (terminal computer) showed a great deal of enthusiasm and, being very familiar with how the terminal works, explained its function at great length, showing a sense of pride at being part of the experment. They would defend it as a superior method of teaching, because of individual terminal - student - relationship. Some, upon questioning, said that this enthusiasm might wear off if it were a daily routine.

The students who were part of the control group (classroom instruction) were very enthusiastic about their teacher in the classroom and defended their method by stating that a terminal "has no humor," or "that their teacher invents new methods of instruction all the time." All of them stated that they would like to try the terminal method but only as an experiment.

2

THE FOLLOWING STRUCTURED QUESTIONS WERE ASKED TO DETERMINE THE UNDERSTANDING AND RETENTION OF ECONOMIC CONCEPTS

1. "What does the word 'economy' mean to you?" "Describe it in your own words."

   Probe for: the management of income and expenditures of private business, community or government. A system of producing, distributing and consuming wealth.

2. "What does Gross National Product mean?"

   Probe for: a country's total production.

3. "What is a favorable balance of trade?"

4. "Why is it advantageous for a country to have a favorable balance of trade?"

   Probe for: income exceeds expense; surplus money and its role; gold reserve.

5. "If a country has a sharp increase in population and its Gross National Product remains the same, what can be said about the country's economy?"

   Probe for: standard of living goes down; the reason for it, and how could it be avoided.

6. "How does a strike effect a country's economy?'

   Probe for: decrease of taxes; unfavorable balance of trade; ask specifically about the strike of the rice production workers of Sierra Leone.

7. "How can a prosperous young country raise its Gross National Product, using its own resources?"

   Probe for: increase in production; role of education; importance of technology.

8. "How can an underdeveloped area such as Sierra Leone be helped from the outside to increase its Gross National Product?"

9. "How does a country with an efficient farming system help its industrial growth?"

10. "Why does an inefficient farming system slow down a nation's economic growth?"

    Probe for: reduction of food supply thus raising food prices; the effect of waste of manpower; how does it affect the income of government?"

11. "When could you buy a sail boat for the lowest price: in the spring or autumn?" Explain.

12. "Imagine that you are a manufacturer of bicycles. How could you fully control the prices of your product?"

    Probe for: control re production and distribution; no government interference.

13. "How can a nation like Sierra Leone, without industry and with a primitive agriculture increase its foreign trade?'

    Probe for: increase of scientific farming and how it is applied to the welfare of the country's economy.

14. "Why should a young growing nation emphasize manufacturing?"

    Probe for: increase of employment, thus creating a market in the country; creating consumers - more people are able to buy; country's economy is based on a multitude of consumers goods.

15. "What are cooperative farms?" Explain fully.

16. "Why are cooperatives in Sierra Leone more efficient than individual farms?"

    Probe for: the importance of sharing ideas and machinery.

17. "Cooperatives are best suited to what kind of government or political system?"

18. "What is the importance of education in the development of Sierra Leone's economy?"

    Probe for: training people for skills; scientific farming.

19.

"Farmer's Investment in Labor, Equipment and Land	Bushels of Corn Produced	Average Production in Bushels for each Dollar of Investment
$ 500	600	1.2
1000	1400	1.4
1500	2700	1.8
2000	3200	1.6
2500	3500	1.4

At what figure should the farmer stop corn production to have a sound business? Why?"

Probe for: Law of Diminishing Returns.

20. "In order to manage his farm efficiently at what point should the farmer withhold further investment? Why?"

Probe for: the Law of Diminishing Returns.

A five-point scale was devised to measure the amount of understanding and retention of economic concepts. The scale ranges from 1-5.

Excellent	5
Good	4
Good, with some probing	3
Vague, with a lot of probing	2
No understanding	1

SAMPLE RESULTS OF INDIVIDUAL INTERVIEWS WITH SOME SPONTANEOUS RESPONSES QUOTED VERBATIM.* CONTROL GROUP

Student A

1. "flow of money standard of living" - Good.
2. Good, with some probing.
3. "enough money; economy, import and export." - Excellent.
4. "more export more money" - Excellent.
5. "country would have low economy" - Excellent.
6. "economy goes down" - Good.
7. Good, with some probing.
8. "help with goods and money" - Good.
9. Good, with some probing.
10. Good, with some probing.
11. Good, with some probing.
12. Vauge, with a lot of probing.
13. Good, with some probing.
14. "because you make more money in industry" - Exellent.
15. Good, with some probing.
16. "more machines produce more" - Excellent.
17. Good
18. "because you can make better machines" - Excellent.
19. "he makes at that point enough to support his farm and he does not pay as much for labor." - Good.
20. Vague understanding with a lot of probing.

*Scale is not based on spontaneous answers alone but on total response to question.

EXPERIMENTAL GROUP

Student F

1. Good, with some probing.
2. Good, with some probing.
3. Vague, with a lot of probing.
4. Good, with some probing.
5. "economy goes down" - Good.
6. "gives country an unfavorable balance of trade" - Good.
7. "scientific farming; more production" - Excellent.
8. "get men to help from other countries and get equipment" - Excellent.
9. Good understanding with some probing.
10. "it's not producing enough" - Good.
11. "since no one is buying no use in having higher prices that part of the year" - Good.
12. No understanding.
13. "produce and become more efficient" - Good.
14. Vague, with a lot of probing.
15. "farms helping each other" - Good.
16. "people are more trained better informed, better machines" - Excellent
17. Good, with some probing.
18. "economy would go up" - Good.
19. No understanding.
20. No understanding.

RATINGS ON RESPONSES DURING DEPTH INTERVIEWS

CONTROL GROUP

Student	Questions																				Average Score
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Student A	4	3	5	5	5	4	3	4	3	3	3	2	3	5	3	5	4	5	4	2	3.8
Student B	2	4	3	4	3	3	4	5	3	2	2	2	4	3	2	4	4	4	1	1	3.0
Student C	4	3	3	4	5	4	3	5	3	4	3	4	4	4	5	3	2	4	4	1	3.6
Student D	5	3	4	3	4	2	4	4	3	4	3	4	3	5	4	5	3	5	2	4	3.7
Student E	4	1	3	2	2	3	4	5	3	3	3	3	5	5	2	3	3	4	4	2	3.2
	19	14	18	18	19	16	18	23	15	16	14	15	19	22	16	20	16	22	16	10	17.3

EXPERIMENTAL GROUP

Student	Questions																				Average Score
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Student F	3	3	2	3	4	4	5	5	3	4	4	1	4	2	4	5	3	4	1	1	3.3
Student G	3	3	2	3	3	2	4	5	3	3	3	2	4	2	3	3	4	3	1	1	2.9
Student H	2	1	2	2	4	3	4	2	3	4	1	1	4	4	1	1	4	3	1	1	2.4
Student I	2	3	4	3	4	4	4	4	4	3	3	2	4	5	5	5	4	4	2	1	3.5
Student J	5	3	3	5	4	5	5	4	3	5	4	4	5	3	3	3	4	4	1	1	3.7
	15	13	13	16	19	18	22	20	16	19	15	10	21	16	16	17	19	18	6	5	15.8

CONCLUSION

It is extremely interesting to note that the Experimental Group as well as the Control Group showed some understanding in most phases of economy, within the framework of the questions asked. Indeed, it is an amazing feat for children at the ages of 11-12, attending 6th grade, especially so since both the experimental and the control group had very little background and instruction in this subject, namely, economics.

This understanding in economics showed itself in both groups only upon probing in various degrees. This is by no means a spontaneous understanding of the subject matter. Quick understanding of a given question and its correct application is after all the only measure applied to test students.

Both groups were able to comprehend the subject in various degrees of understanding; by probing they had the opportunity to reason these questions out aloud, and thus the learning and understanding process became one.

The Control Group (classroom instruction) showed far greater spontaneous understanding of the subject matter than did the Experimental Group (terminal computer instruction). This understanding was demonstrated by examples and a better knowledge of subject matter.

It may be noteworthy to examine the consistently weak responses given to some questions by the experimental group (i.e. question 19 and 20) dealing with abstract economic concepts and reasonings such as the "Law of Diminishing Returns." A study of why these particular questions proved to be difficult may result in the improvement of terminal instruction.

APPENDIX D

ANALYSIS OF BOCES NO. 1 SUMER AND SIERRA LEONE EXPERIMENTS ON THE SUBJECT OF RETENTION

The following analysis is based upon data for the 24 subjects in the Experimental group and the 26 subjects in the Control group on each of the two games and relates to the post-test scores, the retention scores and the differences, or gains and losses, from the post-test administration to the retention administration.

The Sumer Game Retention Analysis

The comparison of post-test results and retention-test results for the Experimental and Control group on the Sumer Game indicates the following:

(a) The mean score for the Experimental group was higher than the Control group, both at post-test time and at retention-test time.

(b) The Experimental group had overall a high level of retention. There was a loss of only 0.34.

(c) The Control group, though continuing to be behind the Experimental group, gained between post-test time and retention-test time in the amount of an average score of 3.19.

In other words, the Experimental group retention was high, meaning the loss of knowledge was low, but significantly different from the Control group because of the phenomenal gain for that group. This may be viewed in brief in Table I. An analysis of variance in Table II of the differences between post-test and retention-test,

Table I

SUMMARY OF MEANS ON SUMER POST-TEST AND RETENTION-TEST

Group	Post-test (mean)	Retention-test (mean)	Gain or loss (mean)
Experimental	24.42	24.08	- 0.34
Control	19.69	22.88	+ 3.19
Total	21.96	23.46	+ 1.50

Table II

ANALYSIS OF VARIANCE OF GAINS OR LOSSES, SUMER

Source of variance	df	SS	Mean square
Total	49	960.50	------
Between	1	155.13	155.13**
Within	48	805.37	16.78

F = 9.24

** Significant at the one percent level

as between the Experimental and Control groups, indicates that there was definitely a significant difference of differences in test results as shown in Table I. This is equivalent to a t-test of the difference in mean gain or loss of the two groups.

Since it might be supposed that the gain of the Control group, rather than a loss, and the fairly static level of the higher scoring Experimental group, without a gain but with a minor loss in retention, might be due to the fact that the higher scoring Experimental group had less opportunity of gaining (because of the effects outside of the experiment) than was possible for the Control group. In other words, the opportunity to gain or lose might be correlated with the initial condition of the subject prior to the elapse of time between post-test and retention-test. As a matter of fact, there was, within the two groups combined, an overall negative correlation of - .264 between the post-test score and the gain or loss between the post-test and the retention-test. This means that the lower a subject's score, the greater his chance to gain, or conversely, the higher a subject's score, the fewer new test items to master or the more likely to lose during the experimental period. This correlation, however, is not significant.

Nevertheless, for purposes of determining whether the highly significant difference in gains or losses between the Experimental and Control group might be attributed to the initial post-test status of the subject, an analysis of covariance was made for purposes of adjusting gain or loss scores for the regression on post-test or initial status. This covariance analysis is summarized in Table III. In this table the dependent variable,

Table III

ANALYSIS OF COVARIANCE, POST-TEST AND GAIN OR LOSS AT RETENTION-TEST, SUMER

Source of variance	df	Sums of squares and products			Errors of estimate		
		Σx^2	Σxy	Σy^2	sums of squares	df	mean square
Total	49	1,777.92	- 498.00	960.50	821.01	48	-----
Between	1	278.55	- 207.87	155.13			
Within	48	1,499.37	- 290.13	805.37	749.23	47	15.94
For test of significance of adjusted means					71.78	1	71.78*

F = 71.78/15.94 = 4.50

* Significant at the five percent level

"Y" is taken as the difference, or gain or loss, between the post-test and retention-test score. The "X" variable is taken as the independent variable, the post-test score. As may be seen in Table III, after adjusting for the correlation of the post-test or the initial state of the subject on gain or loss, there is still a significant difference between the gain or loss means of the two groups. Although without the adjustment, the difference is significant at the one percent level, after adjustment for regression it is shown to have a F-test significance only at the five percent level. In other words, the artifact of potentiality for change, plus or minus, related to how many test items the subject had to learn in between periods of testing, has evidently some bearing, but not a sufficient bearing to eliminate the apparently significant difference in what happened to the two groups during the period between the administration of the two tests.

The Sierra Leone Game Retention Analysis

An identical analysis made of the Sierra Leone Game post-test and retention-test results shows somewhat similar yet different results. As shown in Table IV, there was indeed a loss in understandings for both the Experimental and the Control group. In this case, however, at post-test time the Control group stood higher than the Experimental group. It lost, but not as much as, the Experimental group, as shown in Table IV. Unlike the Sumer Game results, the experimental subjects lost in retention more than the control subjects, the latter standing higher throughout the two test periods.

Table IV

SUMMARY OF MEANS ON SIERRA LEONE POST-TEST AND RETENTION-TEST

Group	Post-test (mean)	Retention-test (mean)	Gain or loss (mean)
Experimental	25.29	22.08	- 3.21
Control	27.27	25.81	- 1.46
Total	26.32	24.02	- 2.30

An analysis of variance of the gains and losses for the two groups, that is, the test of the significance of the difference between the - 3.21 and the - 1.46 shown in Table IV, turns out to indicate that the differences are not significant. This is shown in Table V.

Table V

ANALYSIS OF VARIANCE OF GAINS OR LOSSES, SIERRA LEONE

Source of variance	df	SS	Mean square
Total	49	1,284.50	-----
Between	1	38.08	38.08
Within	48	1,246.42	25.96

F = 1.47

To rule out the possibility again that the initial state of subjects as measured by the post-test score might have a bearing on this result, a covariance analysis was made, as summarized in Table VI.

Table VI

ANALYSIS OF COVARIANCE, POST-TEST AND GAIN OR LOSS AT RETENTION-TEST, SIERRA LEONE

Source of variance	df	Sums of squares and products			Errors of estimate		
		Σx^2	Σxy	Σy^2	sums of squares	df	mean square
Total	49	1,438.88	- 336.20	1,284.50	1,205.95	48	-----
Between	1	48.80	+ 43.11	38.08			
Within	48	1,390.08	- 293.09	1,246.42	1,184.62	47	25.20
For test of significance of adjusted means					21.33	1	21.33

F = .85

The results of this covariance analysis show the following:

(a) The effect of regression of the post-test upon the gain or loss is not significant.

(b) The effect of regression does not eliminate the conclusion that there is not a significant difference between the gains or losses between the two groups, since after allowing for the post-test score, by adjusting through regression, there is still not a significant difference between the two means.

In this case, also, the "Y" variable in Table VI is the difference between the post-test and retention-test scores, and the "X", or independent, variable is the post-test score.

APPENDIX E: SIX UNIQUE FUNCTIONS OF THE COMPUTER IN ECONOMICS GAMES

1. Computational Ability

Calculations may be rapidly performed by the computer without divulging the formulas to the player, providing immediate feedback based upon the player's decisions. In the Sumerian Game, the change in population from one season to the next is obtained using the following formula.

> ΔP, change in population between seasons i and $i+1$, as a function of the number of bushels of grain fed to the people in season i (F), and the population in season i (P):

$$\Delta P(F,P) = \begin{cases} \left[(F/9P) - 1\right]P & \text{if} \quad F/P \leq 9 \\ 0 & \text{if} \quad 9 \leq F/P \leq 15 \\ .01\left[(F/P) - 15\right]P & \text{if} \quad 15 \leq F/P \leq 18 \\ .03P & \text{if} \quad 18 \leq F/P \end{cases}$$

Thus, the player who feeds his people less than 9 bushels/person will face a loss in population while the player who feeds his people more than 18 bushels/person is wasting grain. Feeding exactly 18 bushels per person will allow the greatest rate of population growth without squandering resources.

In a paper-and-pencil version of the Sumerian Game (as opposed to the current version using computer control) the player would learn from glancing at the formula that feeding less than 9 bushels per person causes a population decrease, and that he must feed at least 15 bushels to each person to increase the population. If he knows the formula, the "game" will revert to a mathematical exercise, as the outcomes of alternate decisions will be known before any decision is reached. This destroys the "discovery" method, of allowing the player to learn about the environment by making decisions and solving problems in order to "survive" in it, that forms the foundation for use of this form of the "simulated environment mode" of instruction.

In the second section of the Free Enterprise Game, the player assumes the role of manufacturer of surfboards. Monthly production may be changed by altering the number of workers or the number of machines.

S, the number of surfboards produced in the current month, as a function of the number of workers (W), and the number of machines (M):

$$S(W,M) = \begin{cases} 150W & \text{if } W/M \leq 2 \\ 50W + 200M & \text{if } 2 \leq W/M \leq 4 \\ 30W + 280M & \text{if } 4 \leq W/M \leq 5 \\ 430M & \text{if } 5 \leq W/M \end{cases}$$

This model is designed to demonstrate the principle of diminishing returns: addition of more workers with a fixed number of machines eventually results in less and less output for each additional worker added.

Game strategy at a given point may dictate that full capacity production be instituted, most efficient production, or none at all if there is a sufficient inventory of surfboards on hand. Therefore, knowing what formulae govern production will not guarantee that a player will arrive at a "correct" decision for the situation he faces. However, the calculations involved in finding the results of any decision could be time consuming. In addition to the fact that paper-and-pencil calculations may create boredom and are subject to error, they generally detract from the realism of the simulation by introducing extraneous tasks that are not part of the "role" the player assumes.

It is possible, in the two preceding examples, to overcome some of the difficulties inherent in non-computer-controlled simulations by relying upon mechanical paraphernalia for calculating results: discs, dials, special slide rules, etc. For the next example, the construction and use of such devices would be quite difficult.

In the Sumerian Game, the harvest in bushels (H) in season i+1 depends upon:

a. The amount of seed in bushels (S) planted in season i,

b. The land under cultivation in acres (L) from season i to season i+1,

c. The number of farm workers (W), which is itself a function of the population in season i (P_i) and the population in season i+1. (The number of workers equals $.15(P_i + P_{i+1})$, 30% of the mid-season population.)

The harvest is computed by the formula $H = 4ABF$; A is the factor accounting for the seed planted while B accounts for the size of the labor force. F is a parameter that assumes the value of 1.0 in the initial stages of the game.

To find A(S, L):

If $S/L \leq 6$, $A = S$
If $S/L > 6$, $A = 6L$ (Overplanting for available acreage)

To find B(W, L):

If $L/W \leq 4$, $B = 1$
If $L/W > 4$, $B = 4W/L$ (Insufficient workers for the acreage)

This type of calculation is not readily compatible with simple mechanical computing devices as they cannot allow for fine gradation in input responses: planting 2505 bushels should give a larger harvest than planting 2500 bushels (if planting below the 6 bushel/acre saturation point), yet dials, etc., cannot be built to accommodate such fine differences. The amount of seed planted could vary between 0 and 20,000 bushels, the number of workers between 1 and 300, and the number of acres between 1 and 2000! Furthermore, important information is divulged to the player by an inspection of any mechanical device designed for this purpose: the point of overplanting for the given acreage and the point at which too much land is being cultivated for the size of the population.

The ability to rapidly solve existing formulae is only one feature that computers bring to simulated environments. An additional feature will now be described.

2. Modification of Existing Formulae under Computer Control

In examining the way the harvest is computed in the Sumerian Game, it should be noted that under certain conditions (overplanting and/or insufficient labor force) a substitution of terms is made in the equation; this also occurs in the determination of population change in that game, as well as in calculating surfboard production in the Free Enterprise Game. This actually can be viewed as either substitution of terms (or constants) or as selection of alternate equations. In terms of programming considerations, it may be simpler to branch to an alternate formula if using a FORTRAN-type language, or to calculate and prepare terms separately based upon conditional branches if using a language such as FAP or Autocoder.(2) The ability of the computer to choose an alternate formula for calculating results, on the basis of the short run or long range decisions of the player or some other element built into the model, has been frequently used in the games developed. It is necessary that this be done, in order to more closely to approach reality in the simulations. Several other examples of the utilization of this technique are outlined below.

In the Sumerian Game, if insufficient food has been fed to the people such that (a) more than one half of the population would starve and (b) there remains a large inventory of grain in the warehouse, at mid-season the player is given the message: "Sir, your people are starving and there are NNNN bushels of grain in inventory. How much will you distribute to them?" In the model, it is assumed in this situation that the people have shared the grain in such a way so as to keep the maximum number alive through mid-season. If the ruler releases enough grain from storage, his population loss will not be as severe as it would have been otherwise.

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(2) Use of FORTRAN-type programs for these games will usually require modification of and addition to the FORTRAN "package;" other languages are most effectively used, with custom-designed subroutines to perform arithmetic calculations and transmit/receive from the terminal/typewrite if these are not provided as macros by the language.

In the manufacturing segment of the Free Enterprise Game, the number of surfboards that can be sold in a game month at a given price depends, in part, on whether it is the summer or winter season.

Maximum number of surfboards that can be sold (S_s - summer month, S_w - winter month), as a function of price in dollars (D) and a demand constant (F):

$$S_s = \begin{cases} F(1500 - 100D) & \text{if } P \le \$11.00 \\ F(2600 - 200D) & \text{if } \$11.00 \le P \le \$12.00 \\ F(1400 - 100D) & \text{if } \$12.00 \le P \le \$13.00 \\ F(1140 - 80D) & \text{if } \$13.00 \le P \le \$14.00 \\ F(300 - 20D) & \text{if } \$14.00 \le P \le \$15.00 \\ 0 & \text{if } \$15.00 \le P \end{cases}$$

$$S_w = \begin{cases} F(1425.8 - 102.9D) & \text{if } P \le \$10.75 \\ F(2212.0 - 176D) & \text{if } \$10.75 \le P \le \$12.00 \\ F(1060.0 - 80D) & \text{if } \$12.00 \le P \le \$13.00 \\ F(280.0 - 20D) & \text{if } \$13.00 \le P \le \$14.00 \\ 0 & \text{if. } \$14.00 \le P \end{cases}$$

In the cases above, alternate formulae are available for computing results, selected on the basis of the decision of the player or some other contingency built into the model. In non-computerized simulations, either of two situations would be likely to result: the majority of a player's time would be spent on arithmetic calculations or those facets which complicate the model would be deleted at the expense of realism. Neither of these undesirable circumstances needs to occur if computer control of the model is used.

3. The use of "Random Numbers" in Calculations

In certain real situations, the results of a decision will depend upon many factors in the environment which make the accurate prediction of these results impossible. For example, the inauguration of a sales campaign by a retail store is likely to result in some increase in sales. But whether this sales increase will result in an increase in profits, or even cover the expenses of the campaign itself, cannot be predicted to any degree approaching certainty. This element of "chance" forms an important part of the simulation of a "real" environment.

For the moment, discussion will be postponed on the introduction into simulated environments of problematic situations or events that occur on a random basis. Instead, it is intended to examine in this section how "chance" can enter into the calculation of results of decisions without actually bringing new situations under consideration.

"Random" numbers are prevalent in many board games, and are usually obtained by the throw of a die or the use of some sort of "spinner." Pseudo-random numbers may be quickly generated by any electronic computer by using the power residue method. The simplest approach is construction of a subroutine which, when called, will generate another random number that can be found in some predetermined core location. Some type of programming technique is usually employed to give these numbers what might be called a "non-uniform start," as otherwise the same program, if loaded into the computer on separate occasions, will generate an identical series of random numbers. The CPU clock may be used to modify the numbers; when using remote terminals, random numbers may be repeatedly calculated during any waiting loop associated with terminal read/write delays or "busy" conditions. In the games designed at BOCES, the use of "random" numbers in calculations may be best described by referring to the following examples.

In the Sumerian Game, the grain inventory stored in the warehouse is subject to loss from rotting and rats according to the following formula.

ΔI, change in inventory from season T_i to season T_{i+1} as a function of season (T_{i+1}), the inventory in season T_i (I), and RR, a 2-digit random number from 00 to 99:

$$\Delta I(I, T_{i+1}, RR) = \begin{cases} -.01(RR/3)I & \text{if } T_{i+1} = \text{Fall} \\ -.01(RR/6)I & \text{if } T_{i+1} = \text{Spring} \end{cases}$$

If clay pots are used to store the grain rather than reed baskets, (at a cost of the loss of workers from the field who become potters) this type of depletion of inventory vanishes.

The use of random numbers described in the above example could be readily accomplished in non-computerized simulations through use of pencil-and-paper and a spinner or some other mechanical device. However, in the model about to be described, these methods would not be practical.

In the first segment of the Free Enterprise Game, the player assumes the role of the owner of a toy store. In order for increases in monthly sales to occur, the player must spend some money in any of the following ways: (a) purchase of new kinds of merchandise, (b) purchase of equipment (delivery truck, more adequate display cases, etc.) that could increase sales, and (c) raise monthly expenses for various forms of advertising.

In the case of each purchase of equipment or new kinds of merchandise, the increase in monthly sales is computed by the following formula.

ΔS, increase in monthly sales as a function of dollars spent for equipment or new kinds of merchandise (D) and RRR, a random number between 000 and 999

$$\Delta S(D, RRR) = \begin{cases} .1D & \text{if } 000 \leq RRR \leq 333 \\ .2D & \text{if } 334 \leq RRR \leq 666 \\ .3D & \text{if } 667 \leq RRR \leq 999 \end{cases}$$

For attempts made to raise sales by increasing monthly expenses for advertising, the constants .1, .2, and .3 are replaced by .4, .5, and .6 respectively; D then represents the increase in monthly expenses for the advertising. Such sales increases do not always result in much higher profits, as the cost of goods sold is (initially) 60% of sales.

These sales increases described above will not immediately occur unless the value of merchandise on the shelves is at least 3.6 times as great as the "appropriate" sales level (the level that sales could and should be). The actual sales (SS) in month i will be related to the "appropriate" monthly sales level (SSA) by the following formula:

If $MM/SSA \geq 3.6$, $SS = SSA$
If $MM/SSA < 3.6$, $SS = MM/3.6$

Where MM is the value of the merchandise on the shelves at the beginning of month i.

The record-keeping involved in operating this model without a computer would be extensive. Many of the choices (increased advertising expenses, new types of merchandise) specify only an upper limit to the amount of the possible expenditure, allowing any numerical response within the required range. Furthermore, a record of items accepted and rejected must be kept for future use in assessing long-range consequences of decisions. This could create an information storage/retrieval problem in non-computerized simulations, as there are 72 such items to record. An example of these long-range consequences would be: the player who purchases a delivery truck will find that the resulting increase in profits has been negated by costs for maintenance of the truck. This selective introduction of special situations into the simulated environment will be discussed next.

4. Deterministic Introduction of Situations

There are certain conditions under which it is desirable to control the introduction of problematic situations into the simulated environment, for the sake of both logical and internal consistency. In the Sumerian Game for example, it is unnecessary to consider the introduction of clay pots to prevent grain spoilage if the past loss of inventory due to spoilage has been minimal. If no grain has been planted for the next season, it is hardly possible for a plague of locusts to destroy much of the crop. If no grain is in the warehouse, it is not possible for a fire to rage through the warehouse and destroy a major portion of the inventory. In the retail store part of the Free Enterprise Game, it would be ludicrous to ask the player if he wishes to buy a delivery truck if only $25 is available to spend. If the player has not decided to place his savings in a savings bank, payment of 4% interest should be made.

These situations or problems can be deleted or postponed from appearing if the model is under computer control. In a "board" game, in which such situations would occur by drawing one card from a shuffled deck, the logical consistency of the simulation may be impaired. To avoid this, the normal approach would entail elimination of these situations entirely from non-computerized versions at the expense of realism.

should be made

As play progresses in the Free Enterprise Game, certain additions to monthly store expenses occur. Some of these expenses (increased local taxes, etc.) are beyond the control of the player. Others (delivery truck maintenance, mentioned earlier; higher charges for electricity after purchase of an air conditioner) occur _only_ if such a purchase was made earlier in an effort to increase sales.

"Disasters" occur in the game at pre-determined points: loss of merchandise from fire, injury to a customer who falls on a stray roller skate, etc.

The type of conditional branching described above, switching around situations or around alternative outcomes within situations, does not lend itself to simulations without computer control. To introduce such a combination of "IF's" into a board or card game would seriously detract from the enjoyment to be obtained from playing the game, and prevent the player from becoming absorbed in his role.

One further aspect of simulated environments should also be discussed: the use of "random" occurrences.

5. Probabilistic Introduction of Situations

The use of random numbers to modify calculation of outcomes has been covered earlier. Random numbers are also used to govern the introduction of elements into the game which could occur at any point in play, and have a probability of less than unity of occurring at time T. For example, in the Free Enterprise Game there is a probability of .1 that a "special expense" will occur in a game month. In the program, a random digit is generated and compared to '9'; if an unequal compare results the program continues as usual. In the case of an equal compare the next available (i.e., unused) special expense (cash register repairs, damage by vandals, etc.) is presented.

The "list" of expenses is arranged in such a way that the most costly appear later on the list, on the assumption that sales will increase as play of the game progresses.

The same general technique is used to introduce, with P = .15, special one-month sales campaigns. The "list" of available campaigns has a group at the beginning which are only appropriate in specific months (Christmas displays, Fourth-of-July displays, etc.) while those at the end are usable in any month. In this case, the list is searched for a special monthly bonus that is both appropriate to the current game month and has not been used previously.

An additional note should be injected at this point. While the introduction of these "random" situations adds realism to the simulated environment, if they appear too soon in the game they may detract from the player's understanding of the basic model of the process or processes involved in the environment. Therefore, the games discussed above all are programmed to exclude any of these "random" occurrences from the first few game "months" or "seasons."

6. Peripheral Equipment and Computer Control

Use has been made in the Sumerian and Sierra Leone Games of slide projectors constructed so that any one of 80 slides may be selected and shown under control of the program. These slides fall into two broad categories: those which acquaint the player with the cultural and geographic characteristics of the area, and those which contribute directly to economic understanding (graphs, charts, etc.). In the revised version of the Sumerian Game, a pseudo-random-access tape recorder will be used to present "council meetings" to the player in which the problems facing his city-state are discussed.

However, the greatest addition to these simulated environments will come from the use of cathode-ray tube display devices. These devices could present graphs showing the values attained by one or more of the variables during a specific individual's play of the game. For example, it would be possible to show a player a graph of the price charged and the number of surfboards sold during the past four months of his play of the Free Enterprise Game. Computer control of various types of audio-visual equipment can offer exciting possibilities for increasing the realism of simulated environments.

The models for the games described in this paper virtually preclude the use of any method other than electronic computers for calculations and the logical introduction of situations into the simulated environment. If elements of the environment are excluded from the model, it would be possible to construct some type of "board" game or "pencil-and-paper" game from these models. Even then, "operation" of the model would be cumbersome and the simulated environment would not possess the "realism" afforded to it by computer control. In almost all cases, nonemployment of EDP equipment in the "simulated environment mode" of instruction is done at the expense of simplification of the models of the social and economic environments.

APPENDIX F: SAMPLE SECTION OF SUMERIAN GAME PRINTOUT

```
run 100
Suilxr is running.
Slide 1, hit CR.

     Hello!  Before we begin, will you please type your name, first na
first, then your last name, and then press the Return key.
scott  mclaughlin
     Now, SCOTT, you are ready to operate the Sumerian Economic
Model.




     Imagine that you have just been made Ruler of Lagash, a City-State
of Sumer, in the year 3500 B. C.  Twice yearly your Royal Steward,
Urbaba, will report to you the economic condition of the kingdom.
Guided by these reports, you will decide the use of your grain and
other resources, trying to keep your population stable and well fed.
Between reports, your court advisor will come to you with news of your
kingdom.
     The Steward will use the typewriter to report and ask for your
decisions.  When the "Proceed" light comes on, type your answer in
figures and press "Return".  (If you make a mistake, press "Cancel"
instead and try again).  Good luck!



Initial Economic Report made to the New Ruler of Lagash by his Humble
Steward:
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```
Total population now                            500
Total farm land under cultivation, acres        600
Total grain in inventory, bushels               900
      one season old                            900
      two seasons old                             0
      three seasons old                           0
Total grain just harvested, bushels           13000

Total resources, harvest + inventory          13900

You must now decide how to use your resources.

How many bushels of grain do you wish to FEED your people?
1000
How many bushels of grain do you want PLANTED for the next crop?
2000
This means that 10000 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
2
How many bushels of grain do you wish to FEED your people?
2500
How many bushels of grain do you want PLANTED for the next crop?
9000
This means that 1500 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
2
How many bushels of grain do you wish to FEED your people?
2600
How many bushels of grain do you want PLANTED for the next crop?
9999
This means that 401 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
1
Resulting inventory                            1301

The steward will execute the royal commands and return in 6 months.


Sir, your people don't have enough food to eat and there are 1301
bushels in storage.  Shall we not distribute it to them?  How much?

500
Sir, I am sorry to report that 140 bushels of grain have rotted or
been eaten by rats this past season.

------------------------------------------------------------------

Economic Report of the Ruler's Steward for the SPRING Season in the
year 1 of Luduga I.


Population at previous report                   500
Change in population                           -155
Total population now                            345

The quantity of food the people received last season was far too little.

Harvest last season                           13000
Harvest this season                           14393

Previous inventory                             1301
Change in inventory                            -640
Present inventory                               661
```

```
Total resources, harvest + inventory     15054

You must now decide how to use your resources.

How many bushels of grain do you wish to FEED your people?
300

3500
How many bushels of grain do you want PLANTED for the next crop?
10000
This means that 893 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
1
Resulting inventory                       1554

The steward will execute the royal commands and return in 6 months.


Sir, your population has decreased -31% while the size of your farm
has not changed.

Should I ask the steward to change the number of acres of land under
cultivation?  1-yes or 2-no.
1
You will have 413 acres under cultivation compared to 600 in the past.

Sir, I am sorry to report that 405 bushels of grain have rotted or
been eaten by rats this past season.

----------------------------------------------------------------------

Economic Report of the Ruler's Steward for the FALL Season in the
year 1 of Luduga I.


Population at previous report              345
Change in population                         0
Total population now                       345

The quantity of food the people received last season was too little.

Harvest last season                      14393
Harvest this season                       9824

Previous inventory                        1554
Change in inventory                       -405
Present inventory                         1149


Total resources, harvest + inventory     10973

You must now decide how to use your resources.

How many bushels of grain do you wish to FEED your people?
3600
How many bushels of grain do you want PLANTED for the next crop?
9000
Please sir you dont have that much available
How many bushels of grain do you wish to FEED your people?
3600
How many bushels of grain do you want PLANTED for the next crop?
7000
This meams that 776 bushels must be removed from storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
```

```
2
How many bushels of grain do you wish to FEED your people?
3600
How many bushels of grain do you want PLANTED for the next crop?
6500
This means that 276 bushels must be removed from storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
2
#How many bushels of grain do you wish to FEED your people?
3000
How many bushels of grain do you want PLANTED for the next crop?
600
This means that 6224 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
1
Resulting inventory                        7373

The steward will execute the royal commands and return in 6 months.


As you have noticed, Luduga, by changing your feeding and planting
figures, you can change your population, harvest and inventory.

As your friend and advisor I would like some information from you.
If your people are being fed satisfactorily would you expect your
population to 1-increase 2-decrease 3-stay the same?
1
Of course, you would expect an increase.


Sir, I am sorry to report that 1101 bushels of grain have rotted or
been eaten by rats this past season.

----------------------------------------------------------------------

Economic Report of the Ruler's Steward for the SPRING Season in the
year 2 of Luduga I.


Population at previous report              345
Change in population                       -11
Total population now                       334

The quantity of food the people received last season was far too little

Harvest last season                        9824
Harvest this season                        2381

Previous inventory                         7373
Change in inventory                       -1101
Present inventory                          6272


Total resources, harvest + inventory       8653

You must now decide how to use your resources.

How many bushels of grain do you wish to FEED your people?
4000
How many bushels of grain do you want PLANTED for the next crop?

4500
This means that 6119 bushels must be removed from storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
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```
Resulting inventory                               153

The steward will execute the royal commands and return in 6 months.

Remember, Luduga, any big change in population will affect your
harvest because most of your people are farmers.

Luduga, I fear that the people have angered our god, Ningirsa.  He
alone could have sent that fire across the fields to destroy half of
your crops.  This is a very serious loss.  I trust that you can cover
it from your inventory.

Sir, I am sorry to report that 39 bushels of grain have rotted or
been eaten by rats this past season.
----------------------------------------------------------------------

Economic Report of the Ruler's Steward for the FALL Season in the
year 2 of Luduga I.


Population at previous report                    334
Change in population                               0
Total population now                             334

The quantity of food the people received last season was too little.

Harvest last season                             2381
Harvest this season                             5659

Previous inventory                               153
Change in inventory                              -39
Present inventory                                114


Total resources, harvest + inventory            5773

You must now decide how to use your resources.

How many bushels of grain do you wish to FEED your people?
4500
How many bushels of grain do you want PLANTED for the next crop?
1300
Please sir you dont have that much available
How many bushels of grain do you wish to FEED your people?
4500
How many bushels of grain do you want PLANTED for the next crop?
1000
This means that 159 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
1
Resulting inventory                               273

The steward will execute the royal commands and return in 6 months.


Luduga, I am seeking more information.  If you want your population to
increase, should you 1-feed them more grain 2-feed them less grain?
1
Yes, Luduga, you must feed the people more grain.


Sir, I am sorry to report that 101 bushels of grain have rotted or
been eaten by rats this past season.
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```
Economic Report of the Ruler's Steward for the SPRING Season in the
year 3 of Luduga I.

Population at previous report                      334
Change in population                                 0
Total population now                               334

The quantity of food the people received last season was too little.

Harvest last season                               5659
Harvest this season                               3812

Previous inventory                                 273
Change in inventory                               -101
Present inventory
                                                   172


Total resources, harvest + inventory              3984

You must now decide how to use your resources.

How many bushels of grain do you wish to FEED your people?
3000
How many bushels of grain do you want PLANTED for the next crop?

 300
This means that 512 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
2
5
How many bushels of grain do you wish to FEED your people?
3009
How many bushels of grain do you want PLANTED for the next crop?
3 003
Please retype the number.
3003
Please sir you dont have that much available
How many bushels of grain do you wish to FEED your people?
3000
How many bushels of grain do you want PLANTED for the next crop?
458
5This means that 354 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
2
How many bushels of grain do you wish to FEED your people?
3000
How many bushels of grain do you want PLANTED for the next crop?
700
This means that 112 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
1
Resulting inventory                                284

The steward will execute the royal commands and return in 6 months.


Ne-sag's family became ill with a fever while cutting reeds in the
marsh lands.  I am sorry to report that he and four grown sons have
died.  Fortunately the disease did not spread, but any loss of farmers
is not to be taken lightly.
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     Sir, I am sorry to report that 75 bushels of grain have rotted or
     been eaten by rats this past season.


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Economic Report of the Ruler's Steward for the FALL Season in the
year 3 of Luduga I.


Population at previous report                    334
Change in population                              -5
Total population now                             329

The quantity of food the people received last season was far too little.

Harvest last season                             3812
Harvest this season                             2537

Previous inventory                               284
Change in inventory                              -75
Present inventory                                209

                                                Total resources, harvest + inven
 2746                                                           y       r

You must now decide how to use your resources.

How many bushels of grain do you wish to FEED your people?
2000
How many bushels of grain do you want PLANTED for the next crop?
1200
Please sir you dont have that much available
How many bushels of grain do you wish to FEED your people?

1000
How many bushels of grain do you want PLANTED for the next crop?
1500
This means that 37 bushels must be placed in storage.  Is this all
right?  Do you wish to 1-let your decisions stand or 2-revise them?
1
Resulting inventory                              246

The steward will execute the royal commands and return in 6 months.


I lean heavily upon your wisdom, Luduga, but I am also here to help
you.  Tell me, if your population is increasing, would you expect the
quantity of grain fed to your people to 1-increase 2-decrease?
1
Of course it should increase.  Forgive me if my questions seem
simple.  It is my duty to urge you to see the relationships among the
items in your Steward's reports.


Sir, your people don't have enough food to eat and there are 246
bushels in storage.  Shall we not distribute it to them?  How much?
120
A plague of locusts came upon our fields yesterday.  Fortunately it
was not as severe as it has been in the past.

Sir, I am sorry to report that 26 bushels of grain have rotted or
been eaten by rats this past season.
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